JURASSIC

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1 Main Page

The JUelich RApid Spectral SImulation Code (JURASSIC) is a fast radiative transfer model for the mid-infrared spectral region.This reference manual provides information on the algorithms and data structures used in the code. Further information can be found at: http://www.fz-juelich.de/ias/jsc/jurassic

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2.1 Data Structures

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3.1 File List

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4 Data Structure Documentation

4.1 atm_t Struct Reference

Atmospheric data.

```
#include <jurassic.h>
```

Data Fields

- int np
  Number of data points.
- double time [NP]
  Time (seconds since 2000-01-01T00:00Z).
- double z [NP]
  Altitude [km].
- double lon [NP]
  Longitude [deg].
- double lat [NP]
  Latitude [deg].
- double p [NP]

Pressure [hPa].

- double t [NP]

  Temperature [K].

- double q [NG][NP]

  Volume mixing ratio.

- double k [NW][NP]

  Extinction [1/km].

4.1.1 Detailed Description

Atmospheric data.

Definition at line 219 of file jurassic.h.

4.1.2 Field Documentation

4.1.2.1 int atm_t::np

Number of data points.

Definition at line 222 of file jurassic.h.

4.1.2.2 double atm_t::time[NP]

Time (seconds since 2000-01-01T00:00Z).

Definition at line 225 of file jurassic.h.

4.1.2.3 double atm_t::z[NP]

Altitude [km].

Definition at line 228 of file jurassic.h.

4.1.2.4 double atm_t::lon[NP]

Longitude [deg].

Definition at line 231 of file jurassic.h.

4.1.2.5 double atm_t::lat[NP]

Latitude [deg].

Definition at line 234 of file jurassic.h.

4.1.2.6 double atm_t::p[NP]

Pressure [hPa].

Definition at line 237 of file jurassic.h.

4.1.2.7 double atm_t::t[NP]

Temperature [K].

Definition at line 240 of file jurassic.h.

4.1.2.8 double atm_t::q[NG][NP]

Volume mixing ratio.

Definition at line 243 of file jurassic.h.

4.1.2.9 double atm_t::k[NW][NP]

Extinction [1/km].

Definition at line 246 of file jurassic.h.

The documentation for this struct was generated from the following file:

- jurassic.h

4.2 ctl_t Struct Reference

Forward model control parameters.

`#include <jurassic.h>`

Data Fields

- int ng
  Number of emitters.
- char emitter [NG][LEN]
  Name of each emitter.
- int nd
  Number of radiance channels.
- int nw
  Number of spectral windows.
- double nu [ND]
  Centroid wavenumber of each channel [cm^-1].
- int window [ND]
  Window index of each channel.
- char tblbase [LEN]
  Basename for table files and filter function files.
- double hydz
  Reference height for hydrostatic pressure profile (-999 to skip) [km].
- int ctm_co2
  Compute CO2 continuum (0=no, 1=yes).
- int ctm_h2o
  Compute H2O continuum (0=no, 1=yes).

- int ctm_n2

  Compute N2 continuum (0=no, 1=yes).
- int ctm_o2

  Compute O2 continuum (0=no, 1=yes).
- int refrac

  Take into account refractivity (0=no, 1=yes).
- double rayds

  Maximum step length for raytracing [km].
- double raydz

  Vertical step length for raytracing [km].
- char fov [LEN]

  Field-of-view data file.
- double retp_zmin

  Minimum altitude for pressure retrieval [km].
- double retp_zmax

  Maximum altitude for pressure retrieval [km].
- double rett_zmin

  Minimum altitude for temperature retrieval [km].
- double rett_zmax

  Maximum altitude for temperature retrieval [km].
- double retq_zmin [NG]

  Minimum altitude for volume mixing ratio retrieval [km].
- double retq_zmax [NG]

  Maximum altitude for volume mixing ratio retrieval [km].
- double retk_zmin [NW]

  Minimum altitude for extinction retrieval [km].
- double retk_zmax [NW]

  Maximum altitude for extinction retrieval [km].
- int write_bbt

  Use brightness temperature instead of radiance (0=no, 1=yes).
- int write_matrix

  Write matrix file (0=no, 1=yes).

4.2.1 Detailed Description

Forward model control parameters.

Definition at line 251 of file jurassic.h.

4.2.2 Field Documentation

4.2.2.1 int ctl_t::ng

Number of emitters.

Definition at line 254 of file jurassic.h.

4.2.2.2 char ctl_t::emitter[NG][LEN]

Name of each emitter.

Definition at line 257 of file jurassic.h.

4.2.2.3 int ctl_t::nd

Number of radiance channels.

Definition at line 260 of file jurassic.h.

4.2.2.4 int ctl_t::nw

Number of spectral windows.

Definition at line 263 of file jurassic.h.

4.2.2.5 double ctl_t::nu[ND]

Centroid wavenumber of each channel [cm^-1].

Definition at line 266 of file jurassic.h.

4.2.2.6 int ctl_t::window[ND]

Window index of each channel.

Definition at line 269 of file jurassic.h.

4.2.2.7 char ctl_t::tblbase[LEN]

Basename for table files and filter function files.

Definition at line 272 of file jurassic.h.

4.2.2.8 double ctl_t::hydz

Reference height for hydrostatic pressure profile (-999 to skip) [km].

Definition at line 275 of file jurassic.h.

4.2.2.9 int ctl_t::ctm_co2

Compute CO2 continuum (0=no, 1=yes).

Definition at line 278 of file jurassic.h.

4.2.2.10 int ctl_t::ctm_h2o

Compute H2O continuum (0=no, 1=yes).

Definition at line 281 of file jurassic.h.

4.2.2.11 int ctl_t::ctm_n2

Compute N2 continuum (0=no, 1=yes).

Definition at line 284 of file jurassic.h.

4.2.2.12 int ctl_t::ctm_o2

Compute O2 continuum (0=no, 1=yes).

Definition at line 287 of file jurassic.h.

4.2.2.13 int ctl_t::refrac

Take into account refractivity (0=no, 1=yes).

Definition at line 290 of file jurassic.h.

4.2.2.14 double ctl_t::rayds

Maximum step length for raytracing [km].

Definition at line 293 of file jurassic.h.

4.2.2.15 double ctl_t::raydz

Vertical step length for raytracing [km].

Definition at line 296 of file jurassic.h.

4.2.2.16 char ctl_t::fov[LEN]

Field-of-view data file.

Definition at line 299 of file jurassic.h.

4.2.2.17 double ctl_t::retp_zmin

Minimum altitude for pressure retrieval [km].

Definition at line 302 of file jurassic.h.

4.2.2.18 double ctl_t::retp_zmax

Maximum altitude for pressure retrieval [km].

Definition at line 305 of file jurassic.h.

4.2.2.19 double ctl_t::rett_zmin

Minimum altitude for temperature retrieval [km].

Definition at line 308 of file jurassic.h.

4.2.2.20 double ctl_t::rett_zmax

Maximum altitude for temperature retrieval [km].

Definition at line 311 of file jurassic.h.

4.2.2.21 double ctl_t::retq_zmin[NG]

Minimum altitude for volume mixing ratio retrieval [km].

Definition at line 314 of file jurassic.h.

4.2.2.22 double ctl_t::retq_zmax[NG]

Maximum altitude for volume mixing ratio retrieval [km].

Definition at line 317 of file jurassic.h.

4.2.2.23 double ctl_t::retk_zmin[NW]

Minimum altitude for extinction retrieval [km].

Definition at line 320 of file jurassic.h.

4.2.2.24 double ctl_t::retk_zmax[NW]

Maximum altitude for extinction retrieval [km].

Definition at line 323 of file jurassic.h.

4.2.2.25 int ctl_t::write_bbt

Use brightness temperature instead of radiance (0=no, 1=yes).

Definition at line 326 of file jurassic.h.

4.2.2.26 int ctl_t::write_matrix

Write matrix file (0=no, 1=yes).

Definition at line 329 of file jurassic.h.

The documentation for this struct was generated from the following file:

- jurassic.h

4.3 los_t Struct Reference

Line-of-sight data.

```
#include <jurassic.h>
```

Data Fields

- int np
  Number of LOS points.
- double z [NLOS]
  Altitude [km].
- double lon [NLOS]
  Longitude [deg].
- double lat [NLOS]
  Latitude [deg].
- double p [NLOS]
  Pressure [hPa].
- double t [NLOS]
  Temperature [K].
- double q [NG][NLOS]
  Volume mixing ratio.
- double k [NW][NLOS]
  Extinction [1/km].
- double tsurf
  Surface temperature [K].
- double ds [NLOS]
  Segment length [km].
- double u [NG][NLOS]
  Column density [molecules/cm^ 2].

4.3.1 Detailed Description

Line-of-sight data.

Definition at line 334 of file jurassic.h.

4.3.2 Field Documentation

4.3.2.1 int los_t::np

Number of LOS points.

Definition at line 337 of file jurassic.h.

4.3.2.2 double los_t::z[NLOS]

Altitude [km].

Definition at line 340 of file jurassic.h.

4.3.2.3 double los_t::lon[NLOS]

Longitude [deg].

Definition at line 343 of file jurassic.h.

4.3.2.4 double los_t::lat[NLOS]

Latitude [deg].

Definition at line 346 of file jurassic.h.

4.3.2.5 double los_t::p[NLOS]

Pressure [hPa].

Definition at line 349 of file jurassic.h.

4.3.2.6 double los_t::t[NLOS]

Temperature [K].

Definition at line 352 of file jurassic.h.

4.3.2.7 double los_t::q[NG][NLOS]

Volume mixing ratio.

Definition at line 355 of file jurassic.h.

4.3.2.8 double los_t::k[NW][NLOS]

Extinction [1/km].

Definition at line 358 of file jurassic.h.

4.3.2.9 double los_t::tsurf

Surface temperature [K].

Definition at line 361 of file jurassic.h.

4.3.2.10 double los_t::ds[NLOS]

Segment length [km].

Definition at line 364 of file jurassic.h.

4.3.2.11 double los_t::u[NG][NLOS]

Column density [molecules/cm^2].

Definition at line 367 of file jurassic.h.

The documentation for this struct was generated from the following file:

- jurassic.h

4.4 obs_t Struct Reference

Observation geometry and radiance data.

`#include <jurassic.h>`

Data Fields

- int nr
  Number of ray paths.
- double time [NR]
  Time (seconds since 2000-01-01T00:00Z).
- double obsz [NR]
  Observer altitude [km].
- double obslon [NR]
  Observer longitude [deg].
- double obslat [NR]
  Observer latitude [deg].
- double vpz [NR]
  View point altitude [km].
- double vplon [NR]
  View point longitude [deg].
- double vplat [NR]
  View point latitude [deg].
- double tpz [NR]
  Tangent point altitude [km].
- double tplon [NR]
  Tangent point longitude [deg].
- double tplat [NR]
  Tangent point latitude [deg].
- double tau [ND][NR]
  Transmittance of ray path.
- double rad [ND][NR]
  Radiance [W/(m^2 sr cm^-1)].

4.4.1 Detailed Description

Observation geometry and radiance data.

Definition at line 372 of file jurassic.h.

4.4.2 Field Documentation

4.4.2.1 int obs_t::nr

Number of ray paths.

Definition at line 375 of file jurassic.h.

4.4.2.2 double obs_t::time[NR]

Time (seconds since 2000-01-01T00:00Z).

Definition at line 378 of file jurassic.h.

4.4.2.3 double obs_t::obsz[NR]

Observer altitude [km].

Definition at line 381 of file jurassic.h.

4.4.2.4 double obs_t::obslon[NR]

Observer longitude [deg].

Definition at line 384 of file jurassic.h.

4.4.2.5 double obs_t::obslat[NR]

Observer latitude [deg].

Definition at line 387 of file jurassic.h.

4.4.2.6 double obs_t::vpz[NR]

View point altitude [km].

Definition at line 390 of file jurassic.h.

4.4.2.7 double obs_t::vplon[NR]

View point longitude [deg].

Definition at line 393 of file jurassic.h.

4.4.2.8 double obs_t::vplat[NR]

View point latitude [deg].

Definition at line 396 of file jurassic.h.

4.4.2.9 double obs_t::tpz[NR]

Tangent point altitude [km].

Definition at line 399 of file jurassic.h.

4.4.2.10 double obs_t::tplon[NR]

Tangent point longitude [deg].

Definition at line 402 of file jurassic.h.

4.4.2.11 double obs_t::tplat[NR]

Tangent point latitude [deg].

Definition at line 405 of file jurassic.h.

4.4.2.12 double obs_t::tau[ND][NR]

Transmittance of ray path.

Definition at line 408 of file jurassic.h.

4.4.2.13 double obs_t::rad[ND][NR]

Radiance [W/(m^2 sr cm^-1)].

Definition at line 411 of file jurassic.h.

The documentation for this struct was generated from the following file:

- jurassic.h

4.5 ret_t Struct Reference

Retrieval control parameters.

Data Fields

- char dir [LEN]
  Working directory.
- int kernel_recomp
  Recomputation of kernel matrix (number of iterations).
- int conv_itmax
  Maximum number of iterations.
- double conv_dmin
  Minimum normalized step size in state space.
- int err_ana
  Carry out error analysis (0=no, 1=yes).
- double err_formod [ND]
  Forward model error [%].
- double err_noise [ND]
  Noise error [W/(m^2 sr cm^-1)].
- double err_press
  Pressure error [%].
- double err_press_cz
  Vertical correlation length for pressure error [km].
- double err_press_ch
  Horizontal correlation length for pressure error [km].
- double err_temp
  Temperature error [K].

- double err_temp_cz

  Vertical correlation length for temperature error [km].
- double err_temp_ch

  Horizontal correlation length for temperature error [km].
- double err_q [NG]

  Volume mixing ratio error [%].
- double err_q_cz [NG]

  Vertical correlation length for volume mixing ratio error [km].
- double err_q_ch [NG]

  Horizontal correlation length for volume mixing ratio error [km].
- double err_k [NW]

  Extinction error [1/km].
- double err_k_cz [NW]

  Vertical correlation length for extinction error [km].
- double err_k_ch [NW]

  Horizontal correlation length for extinction error [km].

4.5.1 Detailed Description

Retrieval control parameters.

Definition at line 32 of file retrieval.c.

4.5.2 Field Documentation

4.5.2.1 char ret_t::dir[LEN]

Working directory.

Definition at line 35 of file retrieval.c.

4.5.2.2 int ret_t::kernel_recomp

Recomputation of kernel matrix (number of iterations).

Definition at line 38 of file retrieval.c.

4.5.2.3 int ret_t::conv_itmax

Maximum number of iterations.

Definition at line 41 of file retrieval.c.

4.5.2.4 double ret_t::conv_dmin

Minimum normalized step size in state space.

Definition at line 44 of file retrieval.c.

4.5.2.5 int ret_t::err_ana

Carry out error analysis (0=no, 1=yes).

Definition at line 47 of file retrieval.c.

4.5.2.6 double ret_t::err_formod[ND]

Forward model error [%].

Definition at line 50 of file retrieval.c.

4.5.2.7 double ret_t::err_noise[ND]

Noise error [W/(m^2 sr cm^-1)].

Definition at line 53 of file retrieval.c.

4.5.2.8 double ret_t::err_press

Pressure error [%].

Definition at line 56 of file retrieval.c.

4.5.2.9 double ret_t::err_press_cz

Vertical correlation length for pressure error [km].

Definition at line 59 of file retrieval.c.

4.5.2.10 double ret_t::err_press_ch

Horizontal correlation length for pressure error [km].

Definition at line 62 of file retrieval.c.

4.5.2.11 double ret_t::err_temp

Temperature error [K].

Definition at line 65 of file retrieval.c.

4.5.2.12 double ret_t::err_temp_cz

Vertical correlation length for temperature error [km].

Definition at line 68 of file retrieval.c.

4.5.2.13 double ret_t::err_temp_ch

Horizontal correlation length for temperature error [km].

Definition at line 71 of file retrieval.c.

4.5.2.14 double ret_t::err_q[NG]

Volume mixing ratio error [%].

Definition at line 74 of file retrieval.c.

4.5.2.15 double ret_t::err_q_cz[NG]

Vertical correlation length for volume mixing ratio error [km].

Definition at line 77 of file retrieval.c.

4.5.2.16 double ret_t::err_q_ch[NG]

Horizontal correlation length for volume mixing ratio error [km].

Definition at line 80 of file retrieval.c.

4.5.2.17 double ret_t::err_k[NW]

Extinction error [1/km].

Definition at line 83 of file retrieval.c.

4.5.2.18 double ret_t::err_k_cz[NW]

Vertical correlation length for extinction error [km].

Definition at line 86 of file retrieval.c.

4.5.2.19 double ret_t::err_k_ch[NW]

Horizontal correlation length for extinction error [km].

Definition at line 89 of file retrieval.c.

The documentation for this struct was generated from the following file:

- retrieval.c

4.6 tbl_t Struct Reference

Emissivity look-up tables.

```
#include <jurassic.h>
```

Data Fields

- int np [NG][ND]

  Number of pressure levels.
- int nt [NG][ND][TBLNP]

  Number of temperatures.
- int nu [NG][ND][TBLNP][TBLNT]

  Number of column densities.
- double p [NG][ND][TBLNP]

  Pressure [hPa].
- double t [NG][ND][TBLNP][TBLNT]

  Temperature [K].
- float u [NG][ND][TBLNP][TBLNT][TBLNU]

  Column density [molecules/cm^2].
- float eps [NG][ND][TBLNP][TBLNT][TBLNU]

  Emissivity.
- double st [TBLNS]

  Source function temperature [K].
- double sr [ND][TBLNS]

  Source function radiance [W/(m^2 sr cm^-1)].

4.6.1 Detailed Description

Emissivity look-up tables.

Definition at line 416 of file jurassic.h.

4.6.2 Field Documentation

4.6.2.1 int tbl_t::np[NG][ND]

Number of pressure levels.

Definition at line 419 of file jurassic.h.

4.6.2.2 int tbl_t::nt[NG][ND][TBLNP]

Number of temperatures.

Definition at line 422 of file jurassic.h.

4.6.2.3 int tbl_t::nu[NG][ND][TBLNP][TBLNT]

Number of column densities.

Definition at line 425 of file jurassic.h.

4.6.2.4 double tbl_t::p[NG][ND][TBLNP]

Pressure [hPa].

Definition at line 428 of file jurassic.h.

4.6.2.5 double tbl_t::t[NG][ND][TBLNP][TBLNT]

Temperature [K].

Definition at line 431 of file jurassic.h.

4.6.2.6 float tbl_t::u[NG][ND][TBLNP][TBLNT][TBLNU]

Column density [molecules/cm^2].

Definition at line 434 of file jurassic.h.

4.6.2.7 float tbl_t::eps[NG][ND][TBLNP][TBLNT][TBLNU]

Emissivity.

Definition at line 437 of file jurassic.h.

4.6.2.8 double tbl_t::st[TBLNS]

Source function temperature [K].

Definition at line 440 of file jurassic.h.

4.6.2.9 double tbl_t::sr[ND][TBLNS]

Source function radiance [W/(m^2 sr cm^-1)].

Definition at line 443 of file jurassic.h.

The documentation for this struct was generated from the following file:

- jurassic.h

5 File Documentation

5.1 brightness.c File Reference

Convert radiance to brightness temperature.

Functions

- int main (int argc, char *argv[ ])

5.1.1 Detailed Description

Convert radiance to brightness temperature.

Definition in file brightness.c.

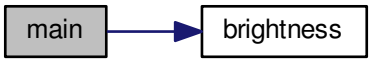
5.1.2 Function Documentation

5.1.2.1 int main (int *argc*, char * *argv[]*)

Definition at line 27 of file brightness.c.

```
00029                {
00030
00031   double nu, rad;
00032
00033   /* Check arguments... */
00034   if (argc < 3)
00035     ERRMSG("Give parameters: <rad> <nu>");
00036
00037   /* Read arguments... */
00038   rad = atof(argv[1]);
00039   nu = atof(argv[2]);
00040
00041   /* Compute brightness temperature... */
00042   printf("%.10g\n", brightness(rad, nu));
00043
00044   return EXIT_SUCCESS;
00045 }
```

Here is the call graph for this function:



5.2 brightness.c

```
00001 /*
00002   This file is part of JURASSIC.
00003
00004   JURASSIC is free software: you can redistribute it and/or modify
00005   it under the terms of the GNU General Public License as published by
00006   the Free Software Foundation, either version 3 of the License, or
00007   (at your option) any later version.
00008
00009   JURASSIC is distributed in the hope that it will be useful,
00010   but WITHOUT ANY WARRANTY; without even the implied warranty of
00011   MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.  See the
00012   GNU General Public License for more details.
00013
00014   You should have received a copy of the GNU General Public License
00015   along with JURASSIC. If not, see <http://www.gnu.org/licenses/>.
00016
00017   Copyright (C) 2003-2015 Forschungszentrum Juelich GmbH
00018 */
00019
00025 #include "jurassic.h"
00026
```

```
00027 int main(
00028   int argc,
00029   char *argv[]) {
00030
00031   double nu, rad;
00032
00033   /* Check arguments... */
00034   if (argc < 3)
00035     ERRMSG("Give parameters: <rad> <nu>");
00036
00037   /* Read arguments... */
00038   rad = atof(argv[1]);
00039   nu = atof(argv[2]);
00040
00041   /* Compute brightness temperature... */
00042   printf("%.10g\n", brightness(rad, nu));
00043
00044   return EXIT_SUCCESS;
00045 }
```

5.3 climatology.c File Reference

Prepare atmospheric data file from climatological data.

Functions

- int main (int argc, char *argv[])

5.3.1 Detailed Description

Prepare atmospheric data file from climatological data.

Definition in file climatology.c.

5.3.2 Function Documentation

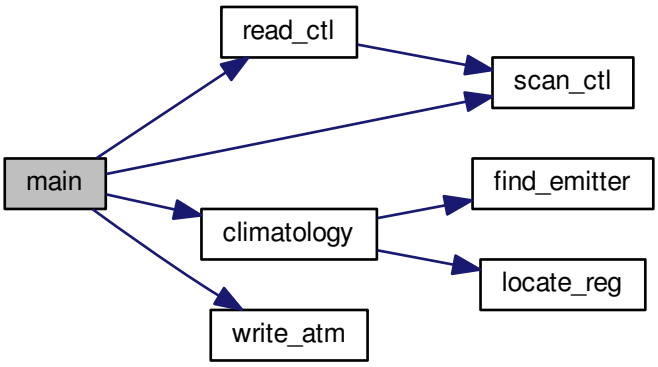
5.3.2.1 int main (int *argc*, char * *argv[]*)

Definition at line 27 of file climatology.c.

```
00029                {
00030
00031   static atm_t atm;
00032   static ctl_t ctl;
00033
00034   double dz, t0, z, z0, z1;
00035
00036   /* Check arguments... */
00037   if (argc < 3)
00038     ERRMSG("Give parameters: <ctl> <atm>");
00039
00040   /* Read control parameters... */
00041   read_ctl(argc, argv, &ctl);
00042   t0 = scan_ctl(argc, argv, "T0", -1, "0", NULL);
00043   z0 = scan_ctl(argc, argv, "Z0", -1, "0", NULL);
00044   z1 = scan_ctl(argc, argv, "Z1", -1, "90", NULL);
00045   dz = scan_ctl(argc, argv, "DZ", -1, "1", NULL);
00046
00047   /* Set atmospheric grid... */
00048   for (z = z0; z <= z1; z += dz) {
00049     atm.time[atm.np] = t0;
00050     atm.z[atm.np] = z;
00051     if ((++atm.np) >= NP)
00052       ERRMSG("Too many atmospheric grid points!");
00053   }
```

```
00054
00055   /* Interpolate climatological data... */
00056   climatology(&ctl, &atm);
00057
00058   /* Write data to disk... */
00059   write_atm(NULL, argv[2], &ctl, &atm);
00060
00061   return EXIT_SUCCESS;
00062 }
```

Here is the call graph for this function:



5.4 climatology.c

```
00001 /*
00002   This file is part of JURASSIC.
00003
00004   JURASSIC is free software: you can redistribute it and/or modify
00005   it under the terms of the GNU General Public License as published by
00006   the Free Software Foundation, either version 3 of the License, or
00007   (at your option) any later version.
00008
00009   JURASSIC is distributed in the hope that it will be useful,
00010   but WITHOUT ANY WARRANTY; without even the implied warranty of
00011   MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.  See the
00012   GNU General Public License for more details.
00013
00014   You should have received a copy of the GNU General Public License
00015   along with JURASSIC. If not, see <http://www.gnu.org/licenses/>.
00016
00017   Copright (C) 2003-2015 Forschungszentrum Juelich GmbH
00018 */
00019
00025 #include "jurassic.h"
00026
00027 int main(
00028   int argc,
00029   char *argv[]) {
00030
00031   static atm_t atm;
00032   static ctl_t ctl;
00033
00034   double dz, t0, z, z0, z1;
00035
00036   /* Check arguments... */
00037   if (argc < 3)
00038     ERRMSG("Give parameters: <ctl> <atm>");
00039
00040   /* Read control parameters... */
00041   read_ctl(argc, argv, &ctl);
00042   t0 = scan_ctl(argc, argv, "T0", -1, "0", NULL);
```

```
00043   z0 = scan_ctl(argc, argv, "Z0", -1, "0", NULL);
00044   z1 = scan_ctl(argc, argv, "Z1", -1, "90", NULL);
00045   dz = scan_ctl(argc, argv, "DZ", -1, "1", NULL);
00046
00047   /* Set atmospheric grid... */
00048   for (z = z0; z <= z1; z += dz) {
00049     atm.time[atm.np] = t0;
00050     atm.z[atm.np] = z;
00051     if ((++atm.np) >= NP)
00052       ERRMSG("Too many atmospheric grid points!");
00053   }
00054
00055   /* Interpolate climatological data... */
00056   climatology(&ctl, &atm);
00057
00058   /* Write data to disk... */
00059   write_atm(NULL, argv[2], &ctl, &atm);
00060
00061   return EXIT_SUCCESS;
00062 }
```

5.5 formod.c File Reference

JURASSIC forward model.

Functions

- void call_formod (ctl_t *ctl, const char *wrkdir, const char *obsfile, const char *atmfile, const char *radfile, const char *task)

  Perform forward model calculations in a single directory.
- int main (int argc, char *argv[])

5.5.1 Detailed Description

JURASSIC forward model.

Definition in file formod.c.

5.5.2 Function Documentation

5.5.2.1 void call_formod (ctl_t * *ctl*, const char * *wrkdir*, const char * *obsfile*, const char * *atmfile*, const char * *radfile*, const char * *task*)

Perform forward model calculations in a single directory.

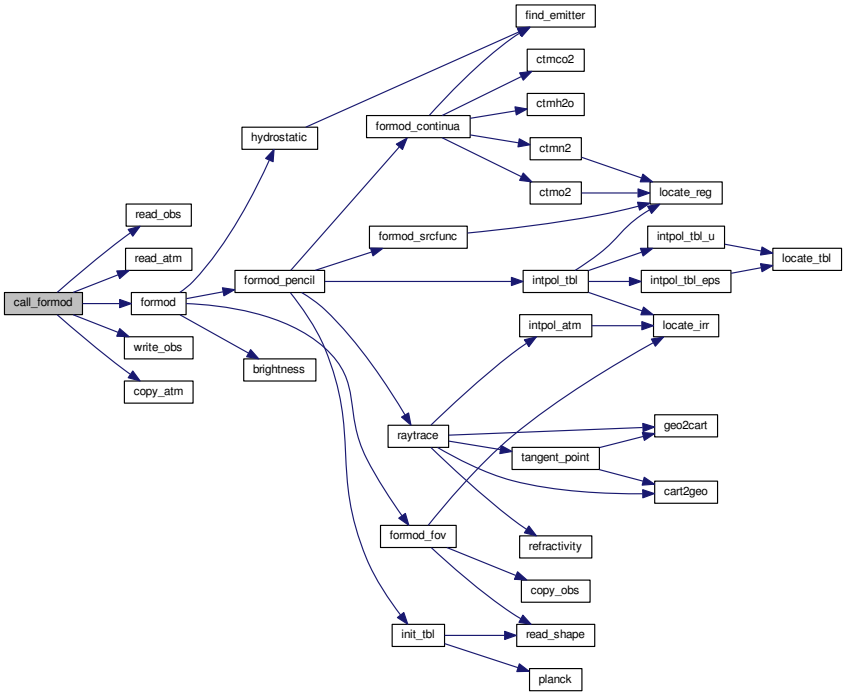
Definition at line 97 of file formod.c.

```
00103                   {
00104
00105   static atm_t atm, atm2;
00106   static obs_t obs, obs2;
00107
00108   char filename[LEN];
00109
00110   int id, ig, ig2, ip, ir, iw;
00111
00112   /* Read observation geometry... */
00113   read_obs(wrkdir, obsfile, ctl, &obs);
00114
00115   /* Read atmospheric data... */
00116   read_atm(wrkdir, atmfile, ctl, &atm);
00117
```

```
00118   /* Compute multiple profiles... */
00119   if (task[0] == 'p' || task[0] == 'P') {
00120
00121     /* Loop over ray paths... */
00122     for (ir = 0; ir < obs.nr; ir++) {
00123
00124       /* Get atmospheric data... */
00125       atm2.np = 0;
00126       for (ip = 0; ip < atm.np; ip++)
00127         if (atm.time[ip] == obs.time[ir]) {
00128           atm2.time[atm2.np] = atm.time[ip];
00129           atm2.z[atm2.np] = atm.z[ip];
00130           atm2.lon[atm2.np] = atm.lon[ip];
00131           atm2.lat[atm2.np] = atm.lat[ip];
00132           atm2.p[atm2.np] = atm.p[ip];
00133           atm2.t[atm2.np] = atm.t[ip];
00134           for (ig = 0; ig < ctl->ng; ig++)
00135             atm2.q[ig][atm2.np] = atm.q[ig][ip];
00136           for (iw = 0; iw < ctl->nw; iw++)
00137             atm2.k[iw][atm2.np] = atm.k[iw][ip];
00138           atm2.np++;
00139         }
00140
00141       /* Get observation data... */
00142       obs2.nr = 1;
00143       obs2.time[0] = obs.time[ir];
00144       obs2.vpz[0] = obs.vpz[ir];
00145       obs2.vplon[0] = obs.vplon[ir];
00146       obs2.vplat[0] = obs.vplat[ir];
00147       obs2.obsz[0] = obs.obsz[ir];
00148       obs2.obslon[0] = obs.obslon[ir];
00149       obs2.obslat[0] = obs.obslat[ir];
00150
00151       /* Check number of data points... */
00152       if (atm2.np > 0) {
00153
00154         /* Call forward model... */
00155         formod(ctl, &atm2, &obs2);
00156
00157         /* Save radiance data... */
00158         for (id = 0; id < ctl->nd; id++) {
00159           obs.rad[id][ir] = obs2.rad[id][0];
00160           obs.tau[id][ir] = obs2.tau[id][0];
00161         }
00162       }
00163     }
00164
00165     /* Write radiance data... */
00166     write_obs(wrkdir, radfile, ctl, &obs);
00167   }
00168
00169   /* Compute single profile... */
00170   else {
00171
00172     /* Call forward model... */
00173     formod(ctl, &atm, &obs);
00174
00175     /* Save radiance data... */
00176     write_obs(wrkdir, radfile, ctl, &obs);
00177
00178     /* Compute contributions... */
00179     if (task[0] == 'c' || task[0] == 'C') {
00180
00181       /* Switch off continua... */
00182       ctl->ctm_co2 = 0;
00183       ctl->ctm_h2o = 0;
00184       ctl->ctm_n2 = 0;
00185       ctl->ctm_o2 = 0;
00186
00187       /* Loop over emitters... */
00188       for (ig = 0; ig < ctl->ng; ig++) {
00189
00190         /* Copy atmospheric data... */
00191         copy_atm(ctl, &atm2, &atm, 0);
00192
00193         /* Set extinction to zero... */
00194         for (iw = 0; iw < ctl->nw; iw++)
00195           for (ip = 0; ip < atm2.np; ip++)
00196             atm2.k[iw][ip] = 0;
00197
00198         /* Set volume mixing ratios to zero... */
00199         for (ig2 = 0; ig2 < ctl->ng; ig2++)
00200           if (ig2 != ig)
00201             for (ip = 0; ip < atm2.np; ip++)
00202               atm2.q[ig2][ip] = 0;
00203
00204         /* Call forward model... */
```

```
00205         formod(ctl, &atm2, &obs);
00206
00207         /* Save radiance data... */
00208         sprintf(filename, "%s.%s", radfile, ctl->emitter[ig]);
00209         write_obs(wrkdir, filename, ctl, &obs);
00210       }
00211
00212       /* Copy atmospheric data... */
00213       copy_atm(ctl, &atm2, &atm, 0);
00214
00215       /* Set volume mixing ratios to zero... */
00216       for (ig = 0; ig < ctl->ng; ig++)
00217         for (ip = 0; ip < atm2.np; ip++)
00218           atm2.q[ig][ip] = 0;
00219
00220       /* Call forward model... */
00221       formod(ctl, &atm2, &obs);
00222
00223       /* Save radiance data... */
00224       sprintf(filename, "%s.EXTINCT", radfile);
00225       write_obs(wrkdir, filename, ctl, &obs);
00226     }
00227
00228     /* Measure CPU-time... */
00229     if (task[0] == 't' || task[0] == 'T') {
00230       TIMER("formod", 1);
00231       formod(ctl, &atm, &obs);
00232       TIMER("formod", 3);
00233     }
00234   }
00235 }
```

Here is the call graph for this function:



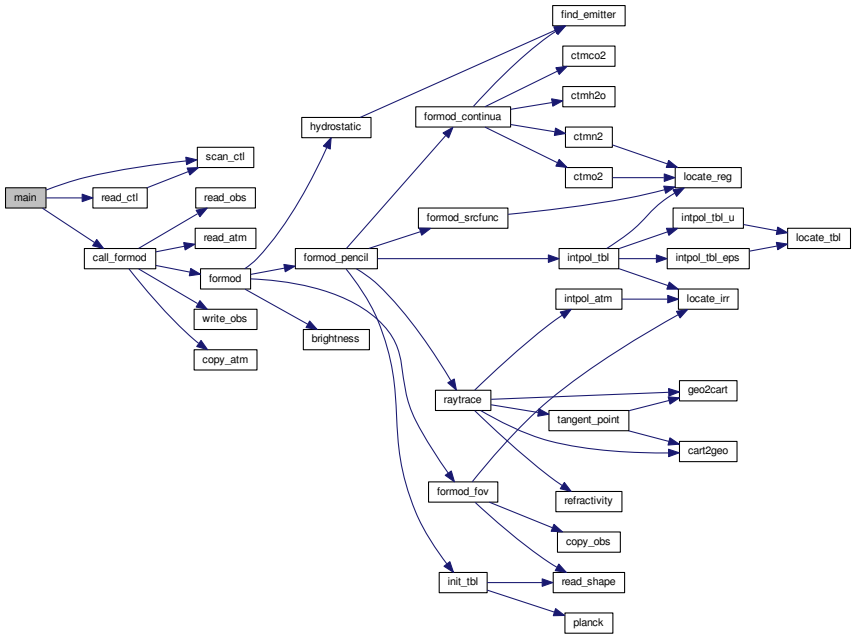
5.5.2.2 int main (int *argc*, char * *argv[ ]*)

Definition at line 44 of file formod.c.

```
00046                 {
```

```
00047
00048   static ctl_t ctl;
00049
00050   FILE *in;
00051
00052   char dirlist[LEN], task[LEN], wrkdir[LEN];
00053
00054   /* Check arguments... */
00055   if (argc < 5)
00056     ERRMSG("Give parameters: <ctl> <obs> <atm> <rad>");
00057
00058   /* Read control parameters... */
00059   read_ctl(argc, argv, &ctl);
00060
00061   /* Get task... */
00062   scan_ctl(argc, argv, "TASK", -1, "-", task);
00063
00064   /* Get dirlist... */
00065   scan_ctl(argc, argv, "DIRLIST", -1, "-", dirlist);
00066
00067   /* Single forward calculation... */
00068   if (dirlist[0] == '-')
00069     call_formod(&ctl, NULL, argv[2], argv[3], argv[4], task);
00070
00071   /* Work on directory list... */
00072   else {
00073
00074     /* Open directory list... */
00075     if (!(in = fopen(dirlist, "r")))
00076       ERRMSG("Cannot open directory list!");
00077
00078     /* Loop over directories... */
00079     while (fscanf(in, "%s", wrkdir) != EOF) {
00080
00081       /* Write info... */
00082       printf("\nWorking directory: %s\n", wrkdir);
00083
00084       /* Call forward model... */
00085       call_formod(&ctl, wrkdir, argv[2], argv[3], argv[4], task);
00086     }
00087
00088     /* Close dirlist... */
00089     fclose(in);
00090   }
00091
00092   return EXIT_SUCCESS;
00093 }
```

Here is the call graph for this function:



5.6 formod.c

```
00001 /*
00002   This file is part of JURASSIC.
00003
00004   JURASSIC is free software: you can redistribute it and/or modify
00005   it under the terms of the GNU General Public License as published by
00006   the Free Software Foundation, either version 3 of the License, or
00007   (at your option) any later version.
00008
00009   JURASSIC is distributed in the hope that it will be useful,
00010   but WITHOUT ANY WARRANTY; without even the implied warranty of
00011   MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.  See the
00012   GNU General Public License for more details.
00013
00014   You should have received a copy of the GNU General Public License
00015   along with JURASSIC. If not, see <http://www.gnu.org/licenses/>.
00016
00017   Copright (C) 2003-2015 Forschungszentrum Juelich GmbH
00018 */
00019
00025 #include "jurassic.h"
00026
00027 /* ------------------------------------------------------------
00028    Functions...
00029    ------------------------------------------------------------ */
00030
00032 void call_formod(
00033   ctl_t * ctl,
00034   const char *wrkdir,
00035   const char *obsfile,
00036   const char *atmfile,
00037   const char *radfile,
00038   const char *task);
00039
00040 /* ------------------------------------------------------------
00041    Main...
00042    ------------------------------------------------------------ */
00043
00044 int main(
00045   int argc,
00046   char *argv[]) {
00047
00048   static ctl_t ctl;
00049
00050   FILE *in;
00051
00052   char dirlist[LEN], task[LEN], wrkdir[LEN];
00053
00054   /* Check arguments... */
00055   if (argc < 5)
00056     ERRMSG("Give parameters: <ctl> <obs> <atm> <rad>");
00057
00058   /* Read control parameters... */
00059   read_ctl(argc, argv, &ctl);
00060
00061   /* Get task... */
00062   scan_ctl(argc, argv, "TASK", -1, "-", task);
00063
00064   /* Get dirlist... */
00065   scan_ctl(argc, argv, "DIRLIST", -1, "-", dirlist);
00066
00067   /* Single forward calculation... */
00068   if (dirlist[0] == '-')
00069     call_formod(&ctl, NULL, argv[2], argv[3], argv[4], task);
00070
00071   /* Work on directory list... */
00072   else {
00073
00074     /* Open directory list... */
00075     if (!(in = fopen(dirlist, "r")))
00076       ERRMSG("Cannot open directory list!");
00077
00078     /* Loop over directories... */
00079     while (fscanf(in, "%s", wrkdir) != EOF) {
00080
00081       /* Write info... */
00082       printf("\nWorking directory: %s\n", wrkdir);
00083
00084       /* Call forward model... */
00085       call_formod(&ctl, wrkdir, argv[2], argv[3], argv[4], task);
00086     }
00087
00088     /* Close dirlist... */
00089     fclose(in);
00090   }
```

```
00091
00092   return EXIT_SUCCESS;
00093 }
00094
00095 /*****************************************************************************/
00096
00097 void call_formod(
00098   ctl_t * ctl,
00099   const char *wrkdir,
00100   const char *obsfile,
00101   const char *atmfile,
00102   const char *radfile,
00103   const char *task) {
00104
00105   static atm_t atm, atm2;
00106   static obs_t obs, obs2;
00107
00108   char filename[LEN];
00109
00110   int id, ig, ig2, ip, ir, iw;
00111
00112   /* Read observation geometry... */
00113   read_obs(wrkdir, obsfile, ctl, &obs);
00114
00115   /* Read atmospheric data... */
00116   read_atm(wrkdir, atmfile, ctl, &atm);
00117
00118   /* Compute multiple profiles... */
00119   if (task[0] == 'p' || task[0] == 'P') {
00120
00121     /* Loop over ray paths... */
00122     for (ir = 0; ir < obs.nr; ir++) {
00123
00124       /* Get atmospheric data... */
00125       atm2.np = 0;
00126       for (ip = 0; ip < atm.np; ip++)
00127         if (atm.time[ip] == obs.time[ir]) {
00128           atm2.time[atm2.np] = atm.time[ip];
00129           atm2.z[atm2.np] = atm.z[ip];
00130           atm2.lon[atm2.np] = atm.lon[ip];
00131           atm2.lat[atm2.np] = atm.lat[ip];
00132           atm2.p[atm2.np] = atm.p[ip];
00133           atm2.t[atm2.np] = atm.t[ip];
00134           for (ig = 0; ig < ctl->ng; ig++)
00135             atm2.q[ig][atm2.np] = atm.q[ig][ip];
00136           for (iw = 0; iw < ctl->nw; iw++)
00137             atm2.k[iw][atm2.np] = atm.k[iw][ip];
00138           atm2.np++;
00139         }
00140
00141       /* Get observation data... */
00142       obs2.nr = 1;
00143       obs2.time[0] = obs.time[ir];
00144       obs2.vpz[0] = obs.vpz[ir];
00145       obs2.vplon[0] = obs.vplon[ir];
00146       obs2.vplat[0] = obs.vplat[ir];
00147       obs2.obsz[0] = obs.obsz[ir];
00148       obs2.obslon[0] = obs.obslon[ir];
00149       obs2.obslat[0] = obs.obslat[ir];
00150
00151       /* Check number of data points... */
00152       if (atm2.np > 0) {
00153
00154         /* Call forward model... */
00155         formod(ctl, &atm2, &obs2);
00156
00157         /* Save radiance data... */
00158         for (id = 0; id < ctl->nd; id++) {
00159           obs.rad[id][ir] = obs2.rad[id][0];
00160           obs.tau[id][ir] = obs2.tau[id][0];
00161         }
00162       }
00163     }
00164
00165     /* Write radiance data... */
00166     write_obs(wrkdir, radfile, ctl, &obs);
00167   }
00168
00169   /* Compute single profile... */
00170   else {
00171
00172     /* Call forward model... */
00173     formod(ctl, &atm, &obs);
00174
00175     /* Save radiance data... */
00176     write_obs(wrkdir, radfile, ctl, &obs);
00177
```

```
00178     /* Compute contributions... */
00179     if (task[0] == 'c' || task[0] == 'C') {
00180
00181       /* Switch off continua... */
00182       ctl->ctm_co2 = 0;
00183       ctl->ctm_h2o = 0;
00184       ctl->ctm_n2 = 0;
00185       ctl->ctm_o2 = 0;
00186
00187       /* Loop over emitters... */
00188       for (ig = 0; ig < ctl->ng; ig++) {
00189
00190         /* Copy atmospheric data... */
00191         copy_atm(ctl, &atm2, &atm, 0);
00192
00193         /* Set extinction to zero... */
00194         for (iw = 0; iw < ctl->nw; iw++)
00195           for (ip = 0; ip < atm2.np; ip++)
00196             atm2.k[iw][ip] = 0;
00197
00198         /* Set volume mixing ratios to zero... */
00199         for (ig2 = 0; ig2 < ctl->ng; ig2++)
00200           if (ig2 != ig)
00201             for (ip = 0; ip < atm2.np; ip++)
00202               atm2.q[ig2][ip] = 0;
00203
00204         /* Call forward model... */
00205         formod(ctl, &atm2, &obs);
00206
00207         /* Save radiance data... */
00208         sprintf(filename, "%s.%s", radfile, ctl->emitter[ig]);
00209         write_obs(wrkdir, filename, ctl, &obs);
00210       }
00211
00212       /* Copy atmospheric data... */
00213       copy_atm(ctl, &atm2, &atm, 0);
00214
00215       /* Set volume mixing ratios to zero... */
00216       for (ig = 0; ig < ctl->ng; ig++)
00217         for (ip = 0; ip < atm2.np; ip++)
00218           atm2.q[ig][ip] = 0;
00219
00220       /* Call forward model... */
00221       formod(ctl, &atm2, &obs);
00222
00223       /* Save radiance data... */
00224       sprintf(filename, "%s.EXTINCT", radfile);
00225       write_obs(wrkdir, filename, ctl, &obs);
00226     }
00227
00228     /* Measure CPU-time... */
00229     if (task[0] == 't' || task[0] == 'T') {
00230       TIMER("formod", 1);
00231       formod(ctl, &atm, &obs);
00232       TIMER("formod", 3);
00233     }
00234   }
00235 }
```

5.7 hydrostatic.c File Reference

Recalculate pressure based on hydrostatic equilibrium.

Functions

- int main (int argc, char *argv[])

5.7.1 Detailed Description

Recalculate pressure based on hydrostatic equilibrium.

Definition in file hydrostatic.c.

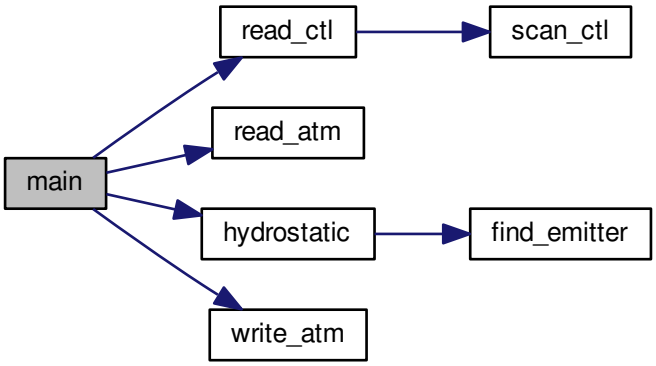
5.7.2 Function Documentation

5.7.2.1 int main (int *argc*, char * *argv[]*)

Definition at line 27 of file hydrostatic.c.

```
00029                {
00030
00031   static atm_t atm;
00032   static ctl_t ctl;
00033
00034   /* Check arguments... */
00035   if (argc < 4)
00036     ERRMSG("Give parameters: <ctl> <atm_in> <atm_hyd>");
00037
00038   /* Read control parameters... */
00039   read_ctl(argc, argv, &ctl);
00040
00041   /* Check reference height... */
00042   if (ctl.hydz < 0)
00043     ERRMSG("Set HYDZ>=0!");
00044
00045   /* Read atmospheric data... */
00046   read_atm(NULL, argv[2], &ctl, &atm);
00047
00048   /* Build atmosphere based on hydrostatic equilibrium... */
00049   hydrostatic(&ctl, &atm);
00050
00051   /* Write atmospheric data... */
00052   write_atm(NULL, argv[3], &ctl, &atm);
00053
00054   return EXIT_SUCCESS;
00055 }
```

Here is the call graph for this function:



5.8 hydrostatic.c

```
00001 /*
00002   This file is part of JURASSIC.
00003
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00008
```

```
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00015   along with JURASSIC. If not, see <http://www.gnu.org/licenses/>.
00016
00017   Copyright (C) 2003-2015 Forschungszentrum Juelich GmbH
00018 */
00019
00025 #include "jurassic.h"
00026
00027 int main(
00028   int argc,
00029   char *argv[]) {
00030
00031   static atm_t atm;
00032   static ctl_t ctl;
00033
00034   /* Check arguments... */
00035   if (argc < 4)
00036     ERRMSG("Give parameters: <ctl> <atm_in> <atm_hyd>");
00037
00038   /* Read control parameters... */
00039   read_ctl(argc, argv, &ctl);
00040
00041   /* Check reference height... */
00042   if (ctl.hydz < 0)
00043     ERRMSG("Set HYDZ>=0!");
00044
00045   /* Read atmospheric data... */
00046   read_atm(NULL, argv[2], &ctl, &atm);
00047
00048   /* Build atmosphere based on hydrostatic equilibrium... */
00049   hydrostatic(&ctl, &atm);
00050
00051   /* Write atmospheric data... */
00052   write_atm(NULL, argv[3], &ctl, &atm);
00053
00054   return EXIT_SUCCESS;
00055 }
```

5.9 interpolate.c File Reference

Interpolate atmospheric data to another spatial grid.

Functions

- int main (int argc, char *argv[])

5.9.1 Detailed Description

Interpolate atmospheric data to another spatial grid.

Definition in file interpolate.c.

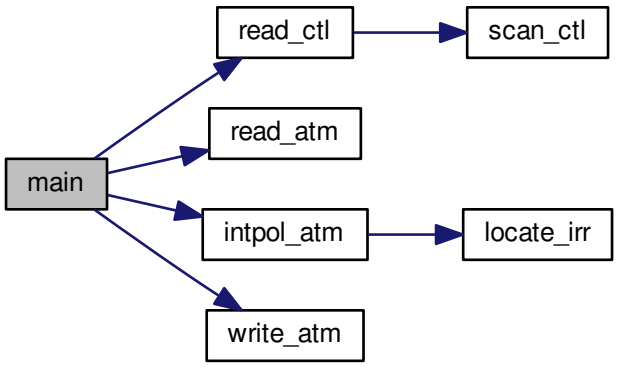
5.9.2 Function Documentation

5.9.2.1 int main (int *argc*, char * *argv[]*)

Definition at line 27 of file interpolate.c.

```
00029                 {
00030
00031   static atm_t atm_in, atm_pts;
00032   static ctl_t ctl;
00033
00034   double k[NW], q[NG];
00035
00036   int ig, ip, iw;
00037
00038   /* Interpolate atmospheric data... */
00039
00040   /* Check arguments... */
00041   if (argc < 5)
00042     ERRMSG("Give parameters: <ctl> <atm_in> <atm_pts> <atm_out>");
00043
00044   /* Read control parameters... */
00045   read_ctl(argc, argv, &ctl);
00046
00047   /* Read atmospheric data... */
00048   read_atm(NULL, argv[2], &ctl, &atm_in);
00049   read_atm(NULL, argv[3], &ctl, &atm_pts);
00050
00051   /* Interpolate atmospheric data... */
00052   for (ip = 0; ip < atm_pts.np; ip++) {
00053     intpol_atm(&ctl, &atm_in, atm_pts.z[ip],
00054                &atm_pts.p[ip], &atm_pts.t[ip], q, k);
00055     for (ig = 0; ig < ctl.ng; ig++)
00056       atm_pts.q[ig][ip] = q[ig];
00057     for (iw = 0; iw < ctl.nw; iw++)
00058       atm_pts.k[iw][ip] = k[iw];
00059   }
00060
00061   /* Save interpolated data... */
00062   write_atm(NULL, argv[4], &ctl, &atm_pts);
00063
00064   return EXIT_SUCCESS;
00065 }
```

Here is the call graph for this function:



5.10 interpolate.c

```
00001 /*
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00005   it under the terms of the GNU General Public License as published by
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00015   along with JURASSIC. If not, see <http://www.gnu.org/licenses/>.
00016
00017   Copyright (C) 2003-2015 Forschungszentrum Juelich GmbH
00018 */
00019
00025 #include "jurassic.h"
00026
00027 int main(
00028   int argc,
00029   char *argv[]) {
00030
00031   static atm_t atm_in, atm_pts;
00032   static ctl_t ctl;
00033
00034   double k[NW], q[NG];
00035
00036   int ig, ip, iw;
00037
00038   /* Interpolate atmospheric data... */
00039
00040   /* Check arguments... */
00041   if (argc < 5)
00042     ERRMSG("Give parameters: <ctl> <atm_in> <atm_pts> <atm_out>");
00043
00044   /* Read control parameters... */
00045   read_ctl(argc, argv, &ctl);
00046
00047   /* Read atmospheric data... */
00048   read_atm(NULL, argv[2], &ctl, &atm_in);
00049   read_atm(NULL, argv[3], &ctl, &atm_pts);
00050
00051   /* Interpolate atmospheric data... */
00052   for (ip = 0; ip < atm_pts.np; ip++) {
00053     intpol_atm(&ctl, &atm_in, atm_pts.z[ip],
00054                &atm_pts.p[ip], &atm_pts.t[ip], q, k);
00055     for (ig = 0; ig < ctl.ng; ig++)
00056       atm_pts.q[ig][ip] = q[ig];
00057     for (iw = 0; iw < ctl.nw; iw++)
00058       atm_pts.k[iw][ip] = k[iw];
00059   }
00060
00061   /* Save interpolated data... */
00062   write_atm(NULL, argv[4], &ctl, &atm_pts);
00063
00064   return EXIT_SUCCESS;
00065 }
```

5.11 jsec2time.c File Reference

Convert Julian seconds to date.

Functions

- int main (int argc, char *argv[])

5.11.1 Detailed Description

Convert Julian seconds to date.

Definition in file jsec2time.c.

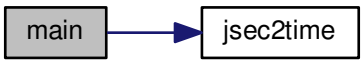
5.11.2 Function Documentation

5.11.2.1 int main (int *argc*, char * *argv[]*)

Definition at line 27 of file jsec2time.c.

```
00029                 {
00030
00031   double jsec, remain;
00032
00033   int day, hour, min, mon, sec, year;
00034
00035   /* Check arguments... */
00036   if (argc < 2)
00037     ERRMSG("Give parameters: <jsec>");
00038
00039   /* Read arguments... */
00040   jsec = atof(argv[1]);
00041
00042   /* Convert time... */
00043   jsec2time(jsec, &year, &mon, &day, &hour, &min, &sec, &remain);
00044   printf("%d %d %d %d %d %d %g\n", year, mon, day, hour, min, sec, remain);
00045
00046   return EXIT_SUCCESS;
00047 }
```

Here is the call graph for this function:



5.12 jsec2time.c

```
00001 /*
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00015   along with JURASSIC. If not, see <http://www.gnu.org/licenses/>.
00016
00017   Copyright (C) 2003-2015 Forschungszentrum Juelich GmbH
00018 */
00019
00025 #include "jurassic.h"
00026
00027 int main(
00028   int argc,
00029   char *argv[]) {
00030
00031   double jsec, remain;
00032
00033   int day, hour, min, mon, sec, year;
00034
00035   /* Check arguments... */
```

```
00036   if (argc < 2)
00037     ERRMSG("Give parameters: <jsec>");
00038
00039   /* Read arguments... */
00040   jsec = atof(argv[1]);
00041
00042   /* Convert time... */
00043   jsec2time(jsec, &year, &mon, &day, &hour, &min, &sec, &remain);
00044   printf("%d %d %d %d %d %d %g\n", year, mon, day, hour, min, sec, remain);
00045
00046   return EXIT_SUCCESS;
00047 }
```

5.13 jurassic.c File Reference

JURASSIC library definitions.

Functions

- size_t atm2x (ctl_t *ctl, atm_t *atm, gsl_vector *x, int *iqa, int *ipa)

  Compose state vector or parameter vector.
- void atm2x_help (atm_t *atm, double zmin, double zmax, double *value, int val_iqa, gsl_vector *x, int *iqa, int *ipa, size_t *n)

  Add elements to state vector.
- double brightness (double rad, double nu)

  Compute brightness temperature.
- void cart2geo (double *x, double *z, double *lon, double *lat)

  Convert Cartesian coordinates to geolocation.
- void climatology (ctl_t *ctl, atm_t *atm)

  Interpolate climatological data.
- double ctmco2 (double nu, double p, double t, double u)

  Compute carbon dioxide continuum (optical depth).
- double ctmh2o (double nu, double p, double t, double q, double u)

  Compute water vapor continuum (optical depth).
- double ctmn2 (double nu, double p, double t)

  Compute nitrogen continuum (absorption coefficient).
- double ctmo2 (double nu, double p, double t)

  Compute oxygen continuum (absorption coefficient).
- void copy_atm (ctl_t *ctl, atm_t *atm_dest, atm_t *atm_src, int init)

  Copy and initialize atmospheric data.
- void copy_obs (ctl_t *ctl, obs_t *obs_dest, obs_t *obs_src, int init)

  Copy and initialize observation data.
- int find_emitter (ctl_t *ctl, const char *emitter)

  Find index of an emitter.
- void formod (ctl_t *ctl, atm_t *atm, obs_t *obs)

  Determine ray paths and compute radiative transfer.
- void formod_continua (ctl_t *ctl, los_t *los, int ip, double *beta)

  Compute absorption coefficient of continua.
- void formod_fov (ctl_t *ctl, obs_t *obs)

  Apply field of view convolution.
- void formod_pencil (ctl_t *ctl, atm_t *atm, obs_t *obs, int ir)

  Compute radiative transfer for a pencil beam.
- void formod_srcfunc (ctl_t *ctl, tbl_t *tbl, double t, double *src)

  Compute Planck source function.

- void geo2cart (double z, double lon, double lat, double *x)
  Convert geolocation to Cartesian coordinates.
- void hydrostatic (ctl_t *ctl, atm_t *atm)
  Set hydrostatic equilibrium.
- void idx2name (ctl_t *ctl, int idx, char *quantity)
  Determine name of state vector quantity for given index.
- void init_tbl (ctl_t *ctl, tbl_t *tbl)
  Initialize look-up tables.
- void intpol_atm (ctl_t *ctl, atm_t *atm, double z, double *p, double *t, double *q, double *k)
  Interpolate atmospheric data.
- void intpol_tbl (ctl_t *ctl, tbl_t *tbl, los_t *los, int ip, double tau_path[NG][ND], double tau_seg[ND])
  Get transmittance from look-up tables.
- double intpol_tbl_eps (tbl_t *tbl, int ig, int id, int ip, int it, double u)
  Interpolate emissivity from look-up tables.
- double intpol_tbl_u (tbl_t *tbl, int ig, int id, int ip, int it, double eps)
  Interpolate column density from look-up tables.
- void jsec2time (double jsec, int *year, int *mon, int *day, int *hour, int *min, int *sec, double *remain)
  Convert seconds to date.
- void kernel (ctl_t *ctl, atm_t *atm, obs_t *obs, gsl_matrix *k)
  Compute Jacobians.
- int locate_irr (double *xx, int n, double x)
  Find array index for irregular grid.
- int locate_reg (double *xx, int n, double x)
  Find array index for regular grid.
- int locate_tbl (float *xx, int n, double x)
  Find array index in float array.
- size_t obs2y (ctl_t *ctl, obs_t *obs, gsl_vector *y, int *ida, int *ira)
  Compose measurement vector.
- double planck (double t, double nu)
  Compute Planck function.
- void raytrace (ctl_t *ctl, atm_t *atm, obs_t *obs, los_t *los, int ir)
  Do ray-tracing to determine LOS.
- void read_atm (const char *dirname, const char *filename, ctl_t *ctl, atm_t *atm)
  Read atmospheric data.
- void read_ctl (int argc, char *argv[ ], ctl_t *ctl)
  Read forward model control parameters.
- void read_matrix (const char *dirname, const char *filename, gsl_matrix *matrix)
  Read matrix.
- void read_obs (const char *dirname, const char *filename, ctl_t *ctl, obs_t *obs)
  Read observation data.
- void read_shape (const char *filename, double *x, double *y, int *n)
  Read shape function.
- double refractivity (double p, double t)
  Compute refractivity (return value is n - 1).
- double scan_ctl (int argc, char *argv[ ], const char *varname, int arridx, const char *defvalue, char *value)
  Search control parameter file for variable entry.
- void tangent_point (los_t *los, double *tpz, double *tplon, double *tplat)
  Find tangent point of a given LOS.
- void time2jsec (int year, int mon, int day, int hour, int min, int sec, double remain, double *jsec)
  Convert date to seconds.
- void timer (const char *name, const char *file, const char *func, int line, int mode)

Measure wall-clock time.

- void write_atm (const char *dirname, const char *filename, ctl_t *ctl, atm_t *atm)

  Write atmospheric data.

- void write_matrix (const char *dirname, const char *filename, ctl_t *ctl, gsl_matrix *matrix, atm_t *atm, obs_t *obs, const char *rowspace, const char *colspace, const char *sort)

  Write matrix.

- void write_obs (const char *dirname, const char *filename, ctl_t *ctl, obs_t *obs)

  Write observation data.

- void x2atm (ctl_t *ctl, gsl_vector *x, atm_t *atm)

  Decompose parameter vector or state vector.

- void x2atm_help (atm_t *atm, double zmin, double zmax, double *value, gsl_vector *x, size_t *n)

  Extract elements from state vector.

- void y2obs (ctl_t *ctl, gsl_vector *y, obs_t *obs)

  Decompose measurement vector.

5.13.1 Detailed Description

JURASSIC library definitions.

Definition in file jurassic.c.

5.13.2 Function Documentation

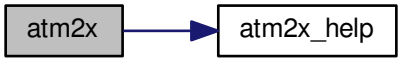
5.13.2.1 size_t atm2x (ctl_t * *ctl*, atm_t * *atm*, gsl_vector * *x*, int * *iqa*, int * *ipa*)

Compose state vector or parameter vector.

Definition at line 29 of file jurassic.c.

```
00034             {
00035
00036   int ig, iw;
00037
00038   size_t n = 0;
00039
00040   /* Add pressure... */
00041   atm2x_help(atm, ctl->retp_zmin, ctl->retp_zmax,
00042              atm->p, IDXP, x, iqa, ipa, &n);
00043
00044   /* Add temperature... */
00045   atm2x_help(atm, ctl->rett_zmin, ctl->rett_zmax,
00046              atm->t, IDXT, x, iqa, ipa, &n);
00047
00048   /* Add volume mixing ratios... */
00049   for (ig = 0; ig < ctl->ng; ig++)
00050     atm2x_help(atm, ctl->retq_zmin[ig], ctl->retq_zmax[ig],
00051                atm->q[ig], IDXQ(ig), x, iqa, ipa, &n);
00052
00053   /* Add extinction... */
00054   for (iw = 0; iw < ctl->nw; iw++)
00055     atm2x_help(atm, ctl->retk_zmin[iw], ctl->retk_zmax[iw],
00056                atm->k[iw], IDXK(iw), x, iqa, ipa, &n);
00057
00058   return n;
00059 }
```

Here is the call graph for this function:



5.13.2.2 void atm2x_help (atm_t * *atm*, double *zmin*, double *zmax*, double * *value*, int *val_iqa*, gsl_vector * *x*, int * *iqa*, int * *ipa*, size_t * *n*)

Add elements to state vector.

Definition at line 63 of file jurassic.c.

```
00072               {
00073
00074   int ip;
00075
00076   /* Add elements to state vector... */
00077   for (ip = 0; ip < atm->np; ip++)
00078     if (atm->z[ip] >= zmin && atm->z[ip] <= zmax) {
00079       if (x != NULL)
00080         gsl_vector_set(x, *n, value[ip]);
00081       if (iqa != NULL)
00082         iqa[*n] = val_iqa;
00083       if (ipa != NULL)
00084         ipa[*n] = ip;
00085       (*n)++;
00086     }
00087 }
```

5.13.2.3 double brightness (double *rad*, double *nu*)

Compute brightness temperature.

Definition at line 91 of file jurassic.c.

```
00093               {
00094
00095   return C2 * nu / gsl_log1p(C1 * POW3(nu) / rad);
00096 }
```

5.13.2.4 void cart2geo (double * *x*, double * *z*, double * *lon*, double * *lat*)

Convert Cartesian coordinates to geolocation.

Definition at line 101 of file jurassic.c.

```
00105                {
00106
00107   double radius;
00108
00109   radius = NORM(x);
00110   *lat = asin(x[2] / radius) * 180 / M_PI;
00111   *lon = atan2(x[1], x[0]) * 180 / M_PI;
00112   *z = radius - RE;
00113 }
```

5.13.2.5 void climatology (ctl_t * *ctl*, atm_t * *atm_mean*)

Interpolate climatological data.

Definition at line 117 of file jurassic.c.

```
00119               {
00120
00121   static double z[121] = {
00122     0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,
00123     20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37,
00124     38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55,
00125     56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73,
00126     74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91,
00127     92, 93, 94, 95, 96, 97, 98, 99, 100, 101, 102, 103, 104, 105, 106, 107,
00128     108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 119, 120
00129   };
00130
00131   static double pre[121] = {
00132     1017, 901.083, 796.45, 702.227, 617.614, 541.644, 473.437, 412.288,
00133     357.603, 308.96, 265.994, 228.348, 195.619, 167.351, 143.039, 122.198,
00134     104.369, 89.141, 76.1528, 65.0804, 55.641, 47.591, 40.7233, 34.8637,
00135     29.8633, 25.5956, 21.9534, 18.8445, 16.1909, 13.9258, 11.9913,
00136     10.34, 8.92988, 7.72454, 6.6924, 5.80701, 5.04654, 4.39238, 3.82902,
00137     3.34337, 2.92413, 2.56128, 2.2464, 1.97258, 1.73384, 1.52519, 1.34242,
00138     1.18197, 1.04086, 0.916546, 0.806832, 0.709875, 0.624101, 0.548176,
00139     0.480974, 0.421507, 0.368904, 0.322408, 0.281386, 0.245249, 0.213465,
00140     0.185549, 0.161072, 0.139644, 0.120913, 0.104568, 0.0903249, 0.0779269,
00141     0.0671493, 0.0577962, 0.0496902, 0.0426736, 0.0366093, 0.0313743,
00142     0.0268598, 0.0229699, 0.0196206, 0.0167399, 0.0142646, 0.0121397,
00143     0.0103181, 0.00875775, 0.00742226, 0.00628076, 0.00530519, 0.00447183,
00144     0.00376124, 0.00315632, 0.00264248, 0.00220738, 0.00184003, 0.00153095,
00145     0.00127204, 0.00105608, 0.000876652, 0.00072798, 0.00060492,
00146     0.000503201, 0.000419226, 0.000349896, 0.000292659, 0.000245421,
00147     0.000206394, 0.000174125, 0.000147441, 0.000125333, 0.000106985,
00148     9.173e-05, 7.90172e-05, 6.84172e-05, 5.95574e-05, 5.21183e-05,
00149     4.58348e-05, 4.05127e-05, 3.59987e-05, 3.21583e-05, 2.88718e-05,
00150     2.60322e-05, 2.35687e-05, 2.14263e-05, 1.95489e-05
00151   };
00152
00153   static double tem[121] = {
00154     285.14, 279.34, 273.91, 268.3, 263.24, 256.55, 250.2, 242.82, 236.17,
00155     229.87, 225.04, 221.19, 218.85, 217.19, 216.2, 215.68, 215.42, 215.55,
00156     215.92, 216.4, 216.93, 217.45, 218, 218.68, 219.39, 220.25, 221.3,
00157     222.41, 223.88, 225.42, 227.2, 229.52, 231.89, 234.51, 236.85, 239.42,
00158     241.94, 244.57, 247.36, 250.32, 253.34, 255.82, 258.27, 260.39,
00159     262.03, 263.45, 264.2, 264.78, 264.67, 264.38, 263.24, 262.03, 260.02,
00160     258.09, 255.63, 253.28, 250.43, 247.81, 245.26, 242.77, 240.38,
00161     237.94, 235.79, 233.53, 231.5, 229.53, 227.6, 225.62, 223.77, 222.06,
00162     220.33, 218.69, 217.18, 215.64, 214.13, 212.52, 210.86, 209.25,
00163     207.49, 205.81, 204.11, 202.22, 200.32, 198.39, 195.92, 193.46,
00164     190.94, 188.31, 185.82, 183.57, 181.43, 179.74, 178.64, 178.1, 178.25,
00165     178.7, 179.41, 180.67, 182.31, 184.18, 186.6, 189.53, 192.66, 196.54,
00166     201.13, 205.93, 211.73, 217.86, 225, 233.53, 242.57, 252.14, 261.48,
00167     272.97, 285.26, 299.12, 312.2, 324.17, 338.34, 352.56, 365.28
00168   };
00169
00170   static double c2h2[121] = {
00171     1.352e-09, 2.83e-10, 1.269e-10, 6.926e-11, 4.346e-11, 2.909e-11,
00172     2.014e-11, 1.363e-11, 8.71e-12, 5.237e-12, 2.718e-12, 1.375e-12,
00173     5.786e-13, 2.16e-13, 7.317e-14, 2.551e-14, 1.055e-14, 4.758e-15,
00174     2.056e-15, 7.703e-16, 2.82e-16, 1.035e-16, 4.382e-17, 1.946e-17,
00175     9.638e-18, 5.2e-18, 2.811e-18, 1.494e-18, 7.925e-19, 4.213e-19,
00176     1.998e-19, 8.78e-20, 3.877e-20, 1.728e-20, 7.743e-21, 3.536e-21,
00177     1.623e-21, 7.508e-22, 3.508e-22, 1.65e-22, 7.837e-23, 3.733e-23,
00178     1.808e-23, 8.77e-24, 4.285e-24, 2.095e-24, 1.032e-24, 5.082e-25,
00179     2.506e-25, 1.236e-25, 6.088e-26, 2.996e-26, 1.465e-26, 0, 0, 0,
00180     0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
00181     0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
00182     0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0
00183   };
00184
00185   static double c2h6[121] = {
00186     2.667e-09, 2.02e-09, 1.658e-09, 1.404e-09, 1.234e-09, 1.109e-09,
00187     1.012e-09, 9.262e-10, 8.472e-10, 7.71e-10, 6.932e-10, 6.216e-10,
00188     5.503e-10, 4.87e-10, 4.342e-10, 3.861e-10, 3.347e-10, 2.772e-10,
00189     2.209e-10, 1.672e-10, 1.197e-10, 8.536e-11, 5.783e-11, 3.846e-11,
00190     2.495e-11, 1.592e-11, 1.017e-11, 6.327e-12, 3.895e-12, 2.403e-12,
00191     1.416e-12, 8.101e-13, 4.649e-13, 2.686e-13, 1.557e-13, 9.14e-14,
00192     5.386e-14, 3.19e-14, 1.903e-14, 1.14e-14, 6.875e-15, 4.154e-15,
00193     2.538e-15, 1.553e-15, 9.548e-16, 5.872e-16, 3.63e-16, 2.244e-16,
00194     1.388e-16, 8.587e-17, 5.308e-17, 3.279e-17, 2.017e-17, 1.238e-17,
00195     7.542e-18, 4.585e-18, 2.776e-18, 1.671e-18, 9.985e-19, 5.937e-19,
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00196     3.518e-19, 2.07e-19, 1.215e-19, 7.06e-20, 4.097e-20, 2.37e-20,
00197     1.363e-20, 7.802e-21, 4.441e-21, 2.523e-21, 1.424e-21, 8.015e-22,
00198     4.497e-22, 2.505e-22, 1.391e-22, 7.691e-23, 4.238e-23, 2.331e-23,
00199     1.274e-23, 6.929e-24, 3.752e-24, 2.02e-24, 1.083e-24, 5.774e-25,
00200     3.041e-25, 1.593e-25, 8.308e-26, 4.299e-26, 2.195e-26, 1.112e-26,
00201     0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
00202     0, 0, 0, 0, 0, 0, 0, 0, 0
00203   };
00204
00205   static double ccl4[121] = {
00206     1.075e-10, 1.075e-10, 1.075e-10, 1.075e-10, 1.075e-10, 1.075e-10,
00207     1.075e-10, 1.075e-10, 1.075e-10, 1.06e-10, 1.024e-10, 9.69e-11,
00208     8.93e-11, 8.078e-11, 7.213e-11, 6.307e-11, 5.383e-11, 4.49e-11,
00209     3.609e-11, 2.705e-11, 1.935e-11, 1.385e-11, 8.35e-12, 5.485e-12,
00210     3.853e-12, 2.22e-12, 5.875e-13, 3.445e-13, 1.015e-13, 6.075e-14,
00211     4.383e-14, 2.692e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14,
00212     1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14,
00213     1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14,
00214     1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14,
00215     1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14,
00216     1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14,
00217     1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14,
00218     1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14,
00219     1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14,
00220     1e-14, 1e-14, 1e-14
00221   };
00222
00223   static double ch4[121] = {
00224     1.864e-06, 1.835e-06, 1.819e-06, 1.805e-06, 1.796e-06, 1.788e-06,
00225     1.782e-06, 1.776e-06, 1.769e-06, 1.761e-06, 1.749e-06, 1.734e-06,
00226     1.716e-06, 1.692e-06, 1.654e-06, 1.61e-06, 1.567e-06, 1.502e-06,
00227     1.433e-06, 1.371e-06, 1.323e-06, 1.277e-06, 1.232e-06, 1.188e-06,
00228     1.147e-06, 1.108e-06, 1.07e-06, 1.027e-06, 9.854e-07, 9.416e-07,
00229     8.933e-07, 8.478e-07, 7.988e-07, 7.515e-07, 7.07e-07, 6.64e-07,
00230     6.239e-07, 5.864e-07, 5.512e-07, 5.184e-07, 4.87e-07, 4.571e-07,
00231     4.296e-07, 4.04e-07, 3.802e-07, 3.578e-07, 3.383e-07, 3.203e-07,
00232     3.032e-07, 2.889e-07, 2.76e-07, 2.635e-07, 2.519e-07, 2.409e-07,
00233     2.302e-07, 2.219e-07, 2.144e-07, 2.071e-07, 1.999e-07, 1.93e-07,
00234     1.862e-07, 1.795e-07, 1.731e-07, 1.668e-07, 1.607e-07, 1.548e-07,
00235     1.49e-07, 1.434e-07, 1.38e-07, 1.328e-07, 1.277e-07, 1.227e-07,
00236     1.18e-07, 1.134e-07, 1.089e-07, 1.046e-07, 1.004e-07, 9.635e-08,
00237     9.245e-08, 8.867e-08, 8.502e-08, 8.15e-08, 7.809e-08, 7.48e-08,
00238     7.159e-08, 6.849e-08, 6.55e-08, 6.262e-08, 5.98e-08, 5.708e-08,
00239     5.448e-08, 5.194e-08, 4.951e-08, 4.72e-08, 4.5e-08, 4.291e-08,
00240     4.093e-08, 3.905e-08, 3.729e-08, 3.563e-08, 3.408e-08, 3.265e-08,
00241     3.128e-08, 2.996e-08, 2.87e-08, 2.76e-08, 2.657e-08, 2.558e-08,
00242     2.467e-08, 2.385e-08, 2.307e-08, 2.234e-08, 2.168e-08, 2.108e-08,
00243     2.05e-08, 1.998e-08, 1.947e-08, 1.902e-08, 1.86e-08, 1.819e-08,
00244     1.782e-08
00245   };
00246
00247   static double clo[121] = {
00248     7.419e-15, 1.061e-14, 1.518e-14, 2.195e-14, 3.175e-14, 4.666e-14,
00249     6.872e-14, 1.03e-13, 1.553e-13, 2.375e-13, 3.664e-13, 5.684e-13,
00250     8.915e-13, 1.402e-12, 2.269e-12, 4.125e-12, 7.501e-12, 1.257e-11,
00251     2.048e-11, 3.338e-11, 5.44e-11, 8.846e-11, 1.008e-10, 1.082e-10,
00252     1.157e-10, 1.232e-10, 1.312e-10, 1.539e-10, 1.822e-10, 2.118e-10,
00253     2.387e-10, 2.687e-10, 2.875e-10, 3.031e-10, 3.23e-10, 3.648e-10,
00254     4.117e-10, 4.477e-10, 4.633e-10, 4.794e-10, 4.95e-10, 5.104e-10,
00255     5.259e-10, 5.062e-10, 4.742e-10, 4.443e-10, 4.051e-10, 3.659e-10,
00256     3.305e-10, 2.911e-10, 2.54e-10, 2.215e-10, 1.927e-10, 1.675e-10,
00257     1.452e-10, 1.259e-10, 1.09e-10, 9.416e-11, 8.119e-11, 6.991e-11,
00258     6.015e-11, 5.163e-11, 4.43e-11, 3.789e-11, 3.24e-11, 2.769e-11,
00259     2.361e-11, 2.011e-11, 1.71e-11, 1.453e-11, 1.233e-11, 1.045e-11,
00260     8.851e-12, 7.48e-12, 6.316e-12, 5.326e-12, 4.487e-12, 3.778e-12,
00261     3.176e-12, 2.665e-12, 2.234e-12, 1.87e-12, 1.563e-12, 1.304e-12,
00262     1.085e-12, 9.007e-13, 7.468e-13, 6.179e-13, 5.092e-13, 4.188e-13,
00263     3.442e-13, 2.816e-13, 2.304e-13, 1.885e-13, 1.542e-13, 1.263e-13,
00264     1.035e-13, 8.5e-14, 7.004e-14, 5.783e-14, 4.795e-14, 4.007e-14,
00265     3.345e-14, 2.792e-14, 2.33e-14, 1.978e-14, 1.686e-14, 1.438e-14,
00266     1.234e-14, 1.07e-14, 9.312e-15, 8.131e-15, 7.164e-15, 6.367e-15,
00267     5.67e-15, 5.088e-15, 4.565e-15, 4.138e-15, 3.769e-15, 3.432e-15,
00268     3.148e-15
00269   };
00270
00271   static double clono2[121] = {
00272     1.011e-13, 1.515e-13, 2.272e-13, 3.446e-13, 5.231e-13, 8.085e-13,
00273     1.253e-12, 1.979e-12, 3.149e-12, 5.092e-12, 8.312e-12, 1.366e-11,
00274     2.272e-11, 3.791e-11, 6.209e-11, 9.101e-11, 1.334e-10, 1.951e-10,
00275     2.853e-10, 3.94e-10, 4.771e-10, 5.771e-10, 6.675e-10, 7.665e-10,
00276     8.504e-10, 8.924e-10, 9.363e-10, 8.923e-10, 8.411e-10, 7.646e-10,
00277     6.525e-10, 5.576e-10, 4.398e-10, 3.403e-10, 2.612e-10, 1.915e-10,
00278     1.407e-10, 1.028e-10, 7.455e-11, 5.42e-11, 3.708e-11, 2.438e-11,
00279     1.618e-11, 1.075e-11, 7.17e-12, 4.784e-12, 3.205e-12, 2.147e-12,
00280     1.44e-12, 9.654e-13, 6.469e-13, 4.332e-13, 2.891e-13, 1.926e-13,
00281     1.274e-13, 8.422e-14, 5.547e-14, 3.636e-14, 2.368e-14, 1.536e-14,
00282     9.937e-15, 6.39e-15, 4.101e-15, 2.61e-15, 1.659e-15, 1.052e-15,
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00283     6.638e-16, 4.172e-16, 2.61e-16, 1.63e-16, 1.013e-16, 6.275e-17,
00284     3.879e-17, 2.383e-17, 1.461e-17, 8.918e-18, 5.43e-18, 3.301e-18,
00285     1.997e-18, 1.203e-18, 7.216e-19, 4.311e-19, 2.564e-19, 1.519e-19,
00286     8.911e-20, 5.203e-20, 3.026e-20, 1.748e-20, 9.99e-21, 5.673e-21,
00287     3.215e-21, 1.799e-21, 1.006e-21, 5.628e-22, 3.146e-22, 1.766e-22,
00288     9.94e-23, 5.614e-23, 3.206e-23, 1.841e-23, 1.071e-23, 6.366e-24,
00289     3.776e-24, 2.238e-24, 1.326e-24, 8.253e-25, 5.201e-25, 3.279e-25,
00290     2.108e-25, 1.395e-25, 9.326e-26, 6.299e-26, 4.365e-26, 3.104e-26,
00291     2.219e-26, 1.621e-26, 1.185e-26, 8.92e-27, 6.804e-27, 5.191e-27,
00292     4.041e-27
00293   };
00294
00295   static double co[121] = {
00296     1.907e-07, 1.553e-07, 1.362e-07, 1.216e-07, 1.114e-07, 1.036e-07,
00297     9.737e-08, 9.152e-08, 8.559e-08, 7.966e-08, 7.277e-08, 6.615e-08,
00298     5.884e-08, 5.22e-08, 4.699e-08, 4.284e-08, 3.776e-08, 3.274e-08,
00299     2.845e-08, 2.479e-08, 2.246e-08, 2.054e-08, 1.991e-08, 1.951e-08,
00300     1.94e-08, 2.009e-08, 2.1e-08, 2.201e-08, 2.322e-08, 2.45e-08,
00301     2.602e-08, 2.73e-08, 2.867e-08, 2.998e-08, 3.135e-08, 3.255e-08,
00302     3.352e-08, 3.426e-08, 3.484e-08, 3.53e-08, 3.593e-08, 3.671e-08,
00303     3.759e-08, 3.945e-08, 4.192e-08, 4.49e-08, 5.03e-08, 5.703e-08,
00304     6.538e-08, 7.878e-08, 9.644e-08, 1.196e-07, 1.498e-07, 1.904e-07,
00305     2.422e-07, 3.055e-07, 3.804e-07, 4.747e-07, 5.899e-07, 7.272e-07,
00306     8.91e-07, 1.071e-06, 1.296e-06, 1.546e-06, 1.823e-06, 2.135e-06,
00307     2.44e-06, 2.714e-06, 2.967e-06, 3.189e-06, 3.391e-06, 3.58e-06,
00308     3.773e-06, 4.022e-06, 4.346e-06, 4.749e-06, 5.199e-06, 5.668e-06,
00309     6.157e-06, 6.688e-06, 7.254e-06, 7.867e-06, 8.539e-06, 9.26e-06,
00310     1.009e-05, 1.119e-05, 1.228e-05, 1.365e-05, 1.506e-05, 1.641e-05,
00311     1.784e-05, 1.952e-05, 2.132e-05, 2.323e-05, 2.531e-05, 2.754e-05,
00312     3.047e-05, 3.459e-05, 3.922e-05, 4.439e-05, 4.825e-05, 5.077e-05,
00313     5.34e-05, 5.618e-05, 5.909e-05, 6.207e-05, 6.519e-05, 6.845e-05,
00314     6.819e-05, 6.726e-05, 6.622e-05, 6.512e-05, 6.671e-05, 6.862e-05,
00315     7.048e-05, 7.264e-05, 7.3e-05, 7.3e-05, 7.3e-05, 7.3e-05, 7.3e-05
00316   };
00317
00318   static double cof2[121] = {
00319     7.5e-14, 1.055e-13, 1.485e-13, 2.111e-13, 3.001e-13, 4.333e-13,
00320     6.269e-13, 9.221e-13, 1.364e-12, 2.046e-12, 3.093e-12, 4.703e-12,
00321     7.225e-12, 1.113e-11, 1.66e-11, 2.088e-11, 2.626e-11, 3.433e-11,
00322     4.549e-11, 5.886e-11, 7.21e-11, 8.824e-11, 1.015e-10, 1.155e-10,
00323     1.288e-10, 1.388e-10, 1.497e-10, 1.554e-10, 1.606e-10, 1.639e-10,
00324     1.64e-10, 1.64e-10, 1.596e-10, 1.542e-10, 1.482e-10, 1.382e-10,
00325     1.289e-10, 1.198e-10, 1.109e-10, 1.026e-10, 9.484e-11, 8.75e-11,
00326     8.086e-11, 7.49e-11, 6.948e-11, 6.446e-11, 5.961e-11, 5.505e-11,
00327     5.085e-11, 4.586e-11, 4.1e-11, 3.665e-11, 3.235e-11, 2.842e-11,
00328     2.491e-11, 2.11e-11, 1.769e-11, 1.479e-11, 1.197e-11, 9.631e-12,
00329     7.74e-12, 6.201e-12, 4.963e-12, 3.956e-12, 3.151e-12, 2.507e-12,
00330     1.99e-12, 1.576e-12, 1.245e-12, 9.83e-13, 7.742e-13, 6.088e-13,
00331     4.782e-13, 3.745e-13, 2.929e-13, 2.286e-13, 1.782e-13, 1.388e-13,
00332     1.079e-13, 8.362e-14, 6.471e-14, 4.996e-14, 3.85e-14, 2.96e-14,
00333     2.265e-14, 1.729e-14, 1.317e-14, 9.998e-15, 7.549e-15, 5.683e-15,
00334     4.273e-15, 3.193e-15, 2.385e-15, 1.782e-15, 1.331e-15, 9.957e-16,
00335     7.461e-16, 5.601e-16, 4.228e-16, 3.201e-16, 2.438e-16, 1.878e-16,
00336     1.445e-16, 1.111e-16, 8.544e-17, 6.734e-17, 5.341e-17, 4.237e-17,
00337     3.394e-17, 2.759e-17, 2.254e-17, 1.851e-17, 1.54e-17, 1.297e-17,
00338     1.096e-17, 9.365e-18, 8e-18, 6.938e-18, 6.056e-18, 5.287e-18,
00339     4.662e-18
00340   };
00341
00342   static double f11[121] = {
00343     2.65e-10, 2.65e-10, 2.65e-10, 2.65e-10, 2.65e-10, 2.65e-10, 2.65e-10,
00344     2.65e-10, 2.65e-10, 2.65e-10, 2.65e-10, 2.65e-10, 2.635e-10, 2.536e-10,
00345     2.44e-10, 2.348e-10, 2.258e-10, 2.153e-10, 2.046e-10, 1.929e-10,
00346     1.782e-10, 1.648e-10, 1.463e-10, 1.291e-10, 1.1e-10, 8.874e-11,
00347     7.165e-11, 5.201e-11, 3.744e-11, 2.577e-11, 1.64e-11, 1.048e-11,
00348     5.993e-12, 3.345e-12, 1.839e-12, 9.264e-13, 4.688e-13, 2.329e-13,
00349     1.129e-13, 5.505e-14, 2.825e-14, 1.492e-14, 7.997e-15, 5.384e-15,
00350     3.988e-15, 2.955e-15, 2.196e-15, 1.632e-15, 1.214e-15, 9.025e-16,
00351     6.708e-16, 4.984e-16, 3.693e-16, 2.733e-16, 2.013e-16, 1.481e-16,
00352     1.087e-16, 7.945e-17, 5.782e-17, 4.195e-17, 3.038e-17, 2.19e-17,
00353     1.577e-17, 1.128e-17, 8.063e-18, 5.753e-18, 4.09e-18, 2.899e-18,
00354     2.048e-18, 1.444e-18, 1.015e-18, 7.12e-19, 4.985e-19, 3.474e-19,
00355     2.417e-19, 1.677e-19, 1.161e-19, 8.029e-20, 5.533e-20, 3.799e-20,
00356     2.602e-20, 1.776e-20, 1.209e-20, 8.202e-21, 5.522e-21, 3.707e-21,
00357     2.48e-21, 1.652e-21, 1.091e-21, 7.174e-22, 4.709e-22, 3.063e-22,
00358     1.991e-22, 1.294e-22, 8.412e-23, 5.483e-23, 3.581e-23, 2.345e-23,
00359     1.548e-23, 1.027e-23, 6.869e-24, 4.673e-24, 3.173e-24, 2.153e-24,
00360     1.461e-24, 1.028e-24, 7.302e-25, 5.188e-25, 3.739e-25, 2.753e-25,
00361     2.043e-25, 1.528e-25, 1.164e-25, 9.041e-26, 7.051e-26, 5.587e-26,
00362     4.428e-26, 3.588e-26, 2.936e-26, 2.402e-26, 1.995e-26
00363   };
00364
00365   static double f12[121] = {
00366     5.45e-10, 5.45e-10, 5.45e-10, 5.45e-10, 5.45e-10, 5.45e-10, 5.45e-10,
00367     5.45e-10, 5.45e-10, 5.45e-10, 5.45e-10, 5.45e-10, 5.429e-10, 5.291e-10,
00368     5.155e-10, 5.022e-10, 4.893e-10, 4.772e-10, 4.655e-10, 4.497e-10,
00369     4.249e-10, 4.015e-10, 3.632e-10, 3.261e-10, 2.858e-10, 2.408e-10,
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00370     2.03e-10, 1.685e-10, 1.4e-10, 1.163e-10, 9.65e-11, 8.02e-11, 6.705e-11,
00371     5.624e-11, 4.764e-11, 4.249e-11, 3.792e-11, 3.315e-11, 2.819e-11,
00372     2.4e-11, 1.999e-11, 1.64e-11, 1.352e-11, 1.14e-11, 9.714e-12,
00373     8.28e-12, 7.176e-12, 6.251e-12, 5.446e-12, 4.72e-12, 4.081e-12,
00374     3.528e-12, 3.08e-12, 2.699e-12, 2.359e-12, 2.111e-12, 1.901e-12,
00375     1.709e-12, 1.534e-12, 1.376e-12, 1.233e-12, 1.103e-12, 9.869e-13,
00376     8.808e-13, 7.859e-13, 7.008e-13, 6.241e-13, 5.553e-13, 4.935e-13,
00377     4.383e-13, 3.889e-13, 3.447e-13, 3.054e-13, 2.702e-13, 2.389e-13,
00378     2.11e-13, 1.862e-13, 1.643e-13, 1.448e-13, 1.274e-13, 1.121e-13,
00379     9.844e-14, 8.638e-14, 7.572e-14, 6.62e-14, 5.782e-14, 5.045e-14,
00380     4.394e-14, 3.817e-14, 3.311e-14, 2.87e-14, 2.48e-14, 2.142e-14,
00381     1.851e-14, 1.599e-14, 1.383e-14, 1.196e-14, 1.036e-14, 9e-15,
00382     7.828e-15, 6.829e-15, 5.992e-15, 5.254e-15, 4.606e-15, 4.037e-15,
00383     3.583e-15, 3.19e-15, 2.841e-15, 2.542e-15, 2.291e-15, 2.07e-15,
00384     1.875e-15, 1.71e-15, 1.57e-15, 1.442e-15, 1.333e-15, 1.232e-15,
00385     1.147e-15, 1.071e-15, 1.001e-15, 9.396e-16
00386   };
00387
00388   static double f14[121] = {
00389     9e-11, 9e-11, 9e-11, 9e-11, 9e-11, 9e-11, 9e-11, 9e-11, 9e-11, 9e-11,
00390     9e-11, 9e-11, 9e-11, 9e-11, 9e-11, 8.91e-11, 8.73e-11, 8.46e-11,
00391     8.19e-11, 7.92e-11, 7.74e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00392     7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00393     7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00394     7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00395     7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00396     7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00397     7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00398     7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00399     7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00400     7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00401     7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00402     7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00403     7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00404     7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00405     7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11
00406   };
00407
00408   static double f22[121] = {
00409     1.4e-10, 1.4e-10, 1.4e-10, 1.4e-10, 1.4e-10, 1.4e-10,
00410     1.4e-10, 1.4e-10, 1.4e-10, 1.372e-10, 1.317e-10, 1.235e-10, 1.153e-10,
00411     1.075e-10, 1.002e-10, 9.332e-11, 8.738e-11, 8.194e-11, 7.7e-11,
00412     7.165e-11, 6.753e-11, 6.341e-11, 5.971e-11, 5.6e-11, 5.229e-11,
00413     4.859e-11, 4.488e-11, 4.118e-11, 3.83e-11, 3.568e-11, 3.308e-11,
00414     3.047e-11, 2.82e-11, 2.594e-11, 2.409e-11, 2.237e-11, 2.065e-11,
00415     1.894e-11, 1.771e-11, 1.647e-11, 1.532e-11, 1.416e-11, 1.332e-11,
00416     1.246e-11, 1.161e-11, 1.087e-11, 1.017e-11, 9.471e-12, 8.853e-12,
00417     8.235e-12, 7.741e-12, 7.247e-12, 6.836e-12, 6.506e-12, 6.176e-12,
00418     5.913e-12, 5.65e-12, 5.419e-12, 5.221e-12, 5.024e-12, 4.859e-12,
00419     4.694e-12, 4.546e-12, 4.414e-12, 4.282e-12, 4.15e-12, 4.019e-12,
00420     3.903e-12, 3.805e-12, 3.706e-12, 3.607e-12, 3.508e-12, 3.41e-12,
00421     3.31e-12, 3.212e-12, 3.129e-12, 3.047e-12, 2.964e-12, 2.882e-12,
00422     2.8e-12, 2.734e-12, 2.668e-12, 2.602e-12, 2.537e-12, 2.471e-12,
00423     2.421e-12, 2.372e-12, 2.322e-12, 2.273e-12, 2.224e-12, 2.182e-12,
00424     2.141e-12, 2.1e-12, 2.059e-12, 2.018e-12, 1.977e-12, 1.935e-12,
00425     1.894e-12, 1.853e-12, 1.812e-12, 1.77e-12, 1.73e-12, 1.688e-12,
00426     1.647e-12, 1.606e-12, 1.565e-12, 1.524e-12, 1.483e-12, 1.441e-12,
00427     1.4e-12, 1.359e-12, 1.317e-12, 1.276e-12, 1.235e-12, 1.194e-12,
00428     1.153e-12, 1.112e-12, 1.071e-12, 1.029e-12, 9.883e-13
00429   };
00430
00431   static double h2o[121] = {
00432     0.01166, 0.008269, 0.005742, 0.003845, 0.00277, 0.001897, 0.001272,
00433     0.000827, 0.000539, 0.0003469, 0.0001579, 3.134e-05, 1.341e-05,
00434     6.764e-06, 4.498e-06, 3.703e-06, 3.724e-06, 3.899e-06, 4.002e-06,
00435     4.122e-06, 4.277e-06, 4.438e-06, 4.558e-06, 4.673e-06, 4.763e-06,
00436     4.809e-06, 4.856e-06, 4.936e-06, 5.021e-06, 5.114e-06, 5.222e-06,
00437     5.331e-06, 5.414e-06, 5.488e-06, 5.563e-06, 5.633e-06, 5.704e-06,
00438     5.767e-06, 5.819e-06, 5.872e-06, 5.914e-06, 5.949e-06, 5.984e-06,
00439     6.015e-06, 6.044e-06, 6.073e-06, 6.104e-06, 6.136e-06, 6.167e-06,
00440     6.189e-06, 6.208e-06, 6.226e-06, 6.212e-06, 6.185e-06, 6.158e-06,
00441     6.114e-06, 6.066e-06, 6.018e-06, 5.877e-06, 5.728e-06, 5.582e-06,
00442     5.437e-06, 5.296e-06, 5.156e-06, 5.02e-06, 4.886e-06, 4.754e-06,
00443     4.625e-06, 4.498e-06, 4.374e-06, 4.242e-06, 4.096e-06, 3.955e-06,
00444     3.817e-06, 3.683e-06, 3.491e-06, 3.204e-06, 2.94e-06, 2.696e-06,
00445     2.47e-06, 2.252e-06, 2.019e-06, 1.808e-06, 1.618e-06, 1.445e-06,
00446     1.285e-06, 1.105e-06, 9.489e-07, 8.121e-07, 6.938e-07, 5.924e-07,
00447     5.04e-07, 4.288e-07, 3.648e-07, 3.103e-07, 2.642e-07, 2.252e-07,
00448     1.921e-07, 1.643e-07, 1.408e-07, 1.211e-07, 1.048e-07, 9.063e-08,
00449     7.835e-08, 6.774e-08, 5.936e-08, 5.221e-08, 4.592e-08, 4.061e-08,
00450     3.62e-08, 3.236e-08, 2.902e-08, 2.62e-08, 2.383e-08, 2.171e-08,
00451     1.989e-08, 1.823e-08, 1.684e-08, 1.562e-08, 1.449e-08, 1.351e-08
00452   };
00453
00454   static double h2o2[121] = {
00455     1.779e-10, 7.938e-10, 8.953e-10, 8.032e-10, 6.564e-10, 5.159e-10,
00456     4.003e-10, 3.026e-10, 2.222e-10, 1.58e-10, 1.044e-10, 6.605e-11,
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00457     3.413e-11, 1.453e-11, 1.062e-11, 1.009e-11, 9.597e-12, 1.175e-11,
00458     1.572e-11, 2.091e-11, 2.746e-11, 3.603e-11, 4.791e-11, 6.387e-11,
00459     8.239e-11, 1.007e-10, 1.23e-10, 1.363e-10, 1.489e-10, 1.585e-10,
00460     1.608e-10, 1.632e-10, 1.576e-10, 1.502e-10, 1.423e-10, 1.302e-10,
00461     1.192e-10, 1.085e-10, 9.795e-11, 8.854e-11, 8.057e-11, 7.36e-11,
00462     6.736e-11, 6.362e-11, 6.087e-11, 5.825e-11, 5.623e-11, 5.443e-11,
00463     5.27e-11, 5.098e-11, 4.931e-11, 4.769e-11, 4.611e-11, 4.458e-11,
00464     4.308e-11, 4.102e-11, 3.887e-11, 3.682e-11, 3.521e-11, 3.369e-11,
00465     3.224e-11, 3.082e-11, 2.946e-11, 2.814e-11, 2.687e-11, 2.566e-11,
00466     2.449e-11, 2.336e-11, 2.227e-11, 2.123e-11, 2.023e-11, 1.927e-11,
00467     1.835e-11, 1.746e-11, 1.661e-11, 1.58e-11, 1.502e-11, 1.428e-11,
00468     1.357e-11, 1.289e-11, 1.224e-11, 1.161e-11, 1.102e-11, 1.045e-11,
00469     9.895e-12, 9.369e-12, 8.866e-12, 8.386e-12, 7.922e-12, 7.479e-12,
00470     7.06e-12, 6.656e-12, 6.274e-12, 5.914e-12, 5.575e-12, 5.257e-12,
00471     4.959e-12, 4.679e-12, 4.42e-12, 4.178e-12, 3.954e-12, 3.75e-12,
00472     3.557e-12, 3.372e-12, 3.198e-12, 3.047e-12, 2.908e-12, 2.775e-12,
00473     2.653e-12, 2.544e-12, 2.442e-12, 2.346e-12, 2.26e-12, 2.183e-12,
00474     2.11e-12, 2.044e-12, 1.98e-12, 1.924e-12, 1.871e-12, 1.821e-12,
00475     1.775e-12
00476   };
00477
00478   static double hcn[121] = {
00479     5.5e-10, 5.5e-10, 5.5e-10, 5.5e-10, 5.5e-10, 5.5e-10, 5.5e-10,
00480     5.5e-10, 5.5e-10, 5.5e-10, 5.5e-10, 5.498e-10, 5.495e-10, 5.493e-10,
00481     5.49e-10, 5.488e-10, 4.717e-10, 3.946e-10, 3.174e-10, 2.4e-10,
00482     1.626e-10, 1.619e-10, 1.612e-10, 1.602e-10, 1.593e-10, 1.582e-10,
00483     1.572e-10, 1.56e-10, 1.549e-10, 1.539e-10, 1.53e-10, 1.519e-10,
00484     1.506e-10, 1.487e-10, 1.467e-10, 1.449e-10, 1.43e-10, 1.413e-10,
00485     1.397e-10, 1.382e-10, 1.368e-10, 1.354e-10, 1.337e-10, 1.315e-10,
00486     1.292e-10, 1.267e-10, 1.241e-10, 1.215e-10, 1.19e-10, 1.165e-10,
00487     1.141e-10, 1.118e-10, 1.096e-10, 1.072e-10, 1.047e-10, 1.021e-10,
00488     9.968e-11, 9.739e-11, 9.539e-11, 9.339e-11, 9.135e-11, 8.898e-11,
00489     8.664e-11, 8.439e-11, 8.249e-11, 8.075e-11, 7.904e-11, 7.735e-11,
00490     7.565e-11, 7.399e-11, 7.245e-11, 7.109e-11, 6.982e-11, 6.863e-11,
00491     6.755e-11, 6.657e-11, 6.587e-11, 6.527e-11, 6.476e-11, 6.428e-11,
00492     6.382e-11, 6.343e-11, 6.307e-11, 6.272e-11, 6.238e-11, 6.205e-11,
00493     6.17e-11, 6.137e-11, 6.102e-11, 6.072e-11, 6.046e-11, 6.03e-11,
00494     6.018e-11, 6.01e-11, 6.001e-11, 5.992e-11, 5.984e-11, 5.975e-11,
00495     5.967e-11, 5.958e-11, 5.95e-11, 5.941e-11, 5.933e-11, 5.925e-11,
00496     5.916e-11, 5.908e-11, 5.899e-11, 5.891e-11, 5.883e-11, 5.874e-11,
00497     5.866e-11, 5.858e-11, 5.85e-11, 5.841e-11, 5.833e-11, 5.825e-11,
00498     5.817e-11, 5.808e-11, 5.8e-11, 5.792e-11, 5.784e-11
00499   };
00500
00501   static double hno3[121] = {
00502     1.809e-10, 7.234e-10, 5.899e-10, 4.342e-10, 3.277e-10, 2.661e-10,
00503     2.35e-10, 2.267e-10, 2.389e-10, 2.651e-10, 3.255e-10, 4.099e-10,
00504     5.42e-10, 6.978e-10, 8.807e-10, 1.112e-09, 1.405e-09, 2.04e-09,
00505     3.111e-09, 4.5e-09, 5.762e-09, 7.37e-09, 7.852e-09, 8.109e-09,
00506     8.067e-09, 7.554e-09, 7.076e-09, 6.268e-09, 5.524e-09, 4.749e-09,
00507     3.909e-09, 3.223e-09, 2.517e-09, 1.942e-09, 1.493e-09, 1.122e-09,
00508     8.449e-10, 6.361e-10, 4.787e-10, 3.611e-10, 2.804e-10, 2.215e-10,
00509     1.758e-10, 1.441e-10, 1.197e-10, 9.953e-11, 8.505e-11, 7.334e-11,
00510     6.325e-11, 5.625e-11, 5.058e-11, 4.548e-11, 4.122e-11, 3.748e-11,
00511     3.402e-11, 3.088e-11, 2.8e-11, 2.536e-11, 2.293e-11, 2.072e-11,
00512     1.871e-11, 1.687e-11, 1.52e-11, 1.368e-11, 1.23e-11, 1.105e-11,
00513     9.922e-12, 8.898e-12, 7.972e-12, 7.139e-12, 6.385e-12, 5.708e-12,
00514     5.099e-12, 4.549e-12, 4.056e-12, 3.613e-12, 3.216e-12, 2.862e-12,
00515     2.544e-12, 2.259e-12, 2.004e-12, 1.776e-12, 1.572e-12, 1.391e-12,
00516     1.227e-12, 1.082e-12, 9.528e-13, 8.379e-13, 7.349e-13, 6.436e-13,
00517     5.634e-13, 4.917e-13, 4.291e-13, 3.745e-13, 3.267e-13, 2.854e-13,
00518     2.494e-13, 2.181e-13, 1.913e-13, 1.68e-13, 1.479e-13, 1.31e-13,
00519     1.159e-13, 1.025e-13, 9.067e-14, 8.113e-14, 7.281e-14, 6.535e-14,
00520     5.892e-14, 5.348e-14, 4.867e-14, 4.439e-14, 4.073e-14, 3.76e-14,
00521     3.476e-14, 3.229e-14, 3e-14, 2.807e-14, 2.635e-14, 2.473e-14,
00522     2.332e-14
00523   };
00524
00525   static double hno4[121] = {
00526     6.118e-12, 3.594e-12, 2.807e-12, 3.04e-12, 4.458e-12, 7.986e-12,
00527     1.509e-11, 2.661e-11, 3.738e-11, 4.652e-11, 4.429e-11, 3.992e-11,
00528     3.347e-11, 3.005e-11, 3.173e-11, 4.055e-11, 5.812e-11, 8.489e-11,
00529     1.19e-10, 1.482e-10, 1.766e-10, 2.103e-10, 2.35e-10, 2.598e-10,
00530     2.801e-10, 2.899e-10, 3e-10, 2.817e-10, 2.617e-10, 2.332e-10,
00531     1.933e-10, 1.605e-10, 1.232e-10, 9.285e-11, 6.941e-11, 4.951e-11,
00532     3.539e-11, 2.402e-11, 1.522e-11, 9.676e-12, 6.056e-12, 3.745e-12,
00533     2.34e-12, 1.463e-12, 9.186e-13, 5.769e-13, 3.322e-13, 1.853e-13,
00534     1.035e-13, 7.173e-14, 5.382e-14, 4.036e-14, 3.401e-14, 2.997e-14,
00535     2.635e-14, 2.316e-14, 2.034e-14, 1.783e-14, 1.56e-14, 1.363e-14,
00536     1.19e-14, 1.037e-14, 9.032e-15, 7.846e-15, 6.813e-15, 5.912e-15,
00537     5.121e-15, 4.431e-15, 3.829e-15, 3.306e-15, 2.851e-15, 2.456e-15,
00538     2.114e-15, 1.816e-15, 1.559e-15, 1.337e-15, 1.146e-15, 9.811e-16,
00539     8.389e-16, 7.162e-16, 6.109e-16, 5.203e-16, 4.425e-16, 3.76e-16,
00540     3.184e-16, 2.692e-16, 2.274e-16, 1.917e-16, 1.61e-16, 1.35e-16,
00541     1.131e-16, 9.437e-17, 7.874e-17, 6.57e-17, 5.481e-17, 4.579e-17,
00542     3.828e-17, 3.204e-17, 2.691e-17, 2.264e-17, 1.912e-17, 1.626e-17,
00543     1.382e-17, 1.174e-17, 9.972e-18, 8.603e-18, 7.45e-18, 6.453e-18,
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00544     5.623e-18, 4.944e-18, 4.361e-18, 3.859e-18, 3.443e-18, 3.096e-18,
00545     2.788e-18, 2.528e-18, 2.293e-18, 2.099e-18, 1.929e-18, 1.773e-18,
00546     1.64e-18
00547   };
00548
00549   static double hocl[121] = {
00550     1.056e-12, 1.194e-12, 1.35e-12, 1.531e-12, 1.737e-12, 1.982e-12,
00551     2.263e-12, 2.599e-12, 2.991e-12, 3.459e-12, 4.012e-12, 4.662e-12,
00552     5.438e-12, 6.35e-12, 7.425e-12, 8.686e-12, 1.016e-11, 1.188e-11,
00553     1.389e-11, 1.659e-11, 2.087e-11, 2.621e-11, 3.265e-11, 4.064e-11,
00554     4.859e-11, 5.441e-11, 6.09e-11, 6.373e-11, 6.611e-11, 6.94e-11,
00555     7.44e-11, 7.97e-11, 8.775e-11, 9.722e-11, 1.064e-10, 1.089e-10,
00556     1.114e-10, 1.106e-10, 1.053e-10, 1.004e-10, 9.006e-11, 7.778e-11,
00557     6.739e-11, 5.636e-11, 4.655e-11, 3.845e-11, 3.042e-11, 2.368e-11,
00558     1.845e-11, 1.442e-11, 1.127e-11, 8.814e-12, 6.544e-12, 4.763e-12,
00559     3.449e-12, 2.612e-12, 1.999e-12, 1.526e-12, 1.16e-12, 8.793e-13,
00560     6.655e-13, 5.017e-13, 3.778e-13, 2.829e-13, 2.117e-13, 1.582e-13,
00561     1.178e-13, 8.755e-14, 6.486e-14, 4.799e-14, 3.54e-14, 2.606e-14,
00562     1.916e-14, 1.403e-14, 1.026e-14, 7.48e-15, 5.446e-15, 3.961e-15,
00563     2.872e-15, 2.076e-15, 1.498e-15, 1.077e-15, 7.726e-16, 5.528e-16,
00564     3.929e-16, 2.785e-16, 1.969e-16, 1.386e-16, 9.69e-17, 6.747e-17,
00565     4.692e-17, 3.236e-17, 2.232e-17, 1.539e-17, 1.061e-17, 7.332e-18,
00566     5.076e-18, 3.522e-18, 2.461e-18, 1.726e-18, 1.22e-18, 8.75e-19,
00567     6.264e-19, 4.482e-19, 3.207e-19, 2.368e-19, 1.762e-19, 1.312e-19,
00568     9.891e-20, 7.595e-20, 5.87e-20, 4.567e-20, 3.612e-20, 2.904e-20,
00569     2.343e-20, 1.917e-20, 1.568e-20, 1.308e-20, 1.1e-20, 9.25e-21,
00570     7.881e-21
00571   };
00572
00573   static double n2o[121] = {
00574     3.17e-07, 3.17e-07, 3.17e-07, 3.17e-07, 3.17e-07, 3.17e-07, 3.17e-07,
00575     3.17e-07, 3.17e-07, 3.17e-07, 3.124e-07, 3.077e-07, 3.03e-07,
00576     2.984e-07, 2.938e-07, 2.892e-07, 2.847e-07, 2.779e-07, 2.705e-07,
00577     2.631e-07, 2.557e-07, 2.484e-07, 2.345e-07, 2.201e-07, 2.01e-07,
00578     1.754e-07, 1.532e-07, 1.329e-07, 1.154e-07, 1.003e-07, 8.735e-08,
00579     7.617e-08, 6.512e-08, 5.547e-08, 4.709e-08, 3.915e-08, 3.259e-08,
00580     2.738e-08, 2.327e-08, 1.98e-08, 1.711e-08, 1.493e-08, 1.306e-08,
00581     1.165e-08, 1.049e-08, 9.439e-09, 8.375e-09, 7.391e-09, 6.525e-09,
00582     5.759e-09, 5.083e-09, 4.485e-09, 3.953e-09, 3.601e-09, 3.27e-09,
00583     2.975e-09, 2.757e-09, 2.556e-09, 2.37e-09, 2.195e-09, 2.032e-09,
00584     1.912e-09, 1.79e-09, 1.679e-09, 1.572e-09, 1.482e-09, 1.402e-09,
00585     1.326e-09, 1.254e-09, 1.187e-09, 1.127e-09, 1.071e-09, 1.02e-09,
00586     9.673e-10, 9.193e-10, 8.752e-10, 8.379e-10, 8.017e-10, 7.66e-10,
00587     7.319e-10, 7.004e-10, 6.721e-10, 6.459e-10, 6.199e-10, 5.942e-10,
00588     5.703e-10, 5.488e-10, 5.283e-10, 5.082e-10, 4.877e-10, 4.696e-10,
00589     4.52e-10, 4.355e-10, 4.198e-10, 4.039e-10, 3.888e-10, 3.754e-10,
00590     3.624e-10, 3.499e-10, 3.381e-10, 3.267e-10, 3.163e-10, 3.058e-10,
00591     2.959e-10, 2.864e-10, 2.77e-10, 2.686e-10, 2.604e-10, 2.534e-10,
00592     2.462e-10, 2.386e-10, 2.318e-10, 2.247e-10, 2.189e-10, 2.133e-10,
00593     2.071e-10, 2.014e-10, 1.955e-10, 1.908e-10, 1.86e-10, 1.817e-10
00594   };
00595
00596   static double n2o5[121] = {
00597     1.231e-11, 3.035e-12, 1.702e-12, 9.877e-13, 8.081e-13, 9.039e-13,
00598     1.169e-12, 1.474e-12, 1.651e-12, 1.795e-12, 1.998e-12, 2.543e-12,
00599     4.398e-12, 7.698e-12, 1.28e-11, 2.131e-11, 3.548e-11, 5.894e-11,
00600     7.645e-11, 1.089e-10, 1.391e-10, 1.886e-10, 2.386e-10, 2.986e-10,
00601     3.487e-10, 3.994e-10, 4.5e-10, 4.6e-10, 4.591e-10, 4.1e-10, 3.488e-10,
00602     2.846e-10, 2.287e-10, 1.696e-10, 1.011e-10, 6.428e-11, 4.324e-11,
00603     2.225e-11, 6.214e-12, 3.608e-12, 8.793e-13, 4.491e-13, 1.04e-13,
00604     6.1e-14, 3.436e-14, 6.671e-15, 1.171e-15, 5.848e-16, 1.212e-16,
00605     1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16,
00606     1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16,
00607     1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16,
00608     1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16,
00609     1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16,
00610     1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16,
00611     1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16,
00612     1e-16, 1e-16
00613   };
00614
00615   static double nh3[121] = {
00616     1e-10, 1e-10, 1e-10, 1e-10, 1e-10, 1e-10, 1e-10, 1e-10, 1e-10, 1e-10,
00617     1e-10, 1e-10, 1e-10, 1e-10, 9.444e-11, 8.488e-11, 7.241e-11, 5.785e-11,
00618     4.178e-11, 3.018e-11, 2.18e-11, 1.574e-11, 1.137e-11, 8.211e-12,
00619     5.973e-12, 4.327e-12, 3.118e-12, 2.234e-12, 1.573e-12, 1.04e-12,
00620     6.762e-13, 4.202e-13, 2.406e-13, 1.335e-13, 6.938e-14, 3.105e-14,
00621     1.609e-14, 1.033e-14, 6.432e-15, 4.031e-15, 2.555e-15, 1.656e-15,
00622     1.115e-15, 7.904e-16, 5.63e-16, 4.048e-16, 2.876e-16, 2.004e-16,
00623     1.356e-16, 9.237e-17, 6.235e-17, 4.223e-17, 3.009e-17, 2.328e-17,
00624     2.002e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17,
00625     1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17,
00626     1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17,
00627     1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17,
00628     1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17,
00629     1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17,
00630     1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17,
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00631     1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17,
00632     1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17,
00633     1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17,
00634     1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17,
00635     1.914e-17
00636   };
00637
00638   static double no[121] = {
00639     2.586e-10, 4.143e-11, 1.566e-11, 9.591e-12, 8.088e-12, 8.462e-12,
00640     1.013e-11, 1.328e-11, 1.855e-11, 2.678e-11, 3.926e-11, 5.464e-11,
00641     7.012e-11, 8.912e-11, 1.127e-10, 1.347e-10, 1.498e-10, 1.544e-10,
00642     1.602e-10, 1.824e-10, 2.078e-10, 2.366e-10, 2.691e-10, 5.141e-10,
00643     8.259e-10, 1.254e-09, 1.849e-09, 2.473e-09, 3.294e-09, 4.16e-09,
00644     5.095e-09, 6.11e-09, 6.93e-09, 7.888e-09, 8.903e-09, 9.713e-09,
00645     1.052e-08, 1.115e-08, 1.173e-08, 1.21e-08, 1.228e-08, 1.239e-08,
00646     1.231e-08, 1.213e-08, 1.192e-08, 1.138e-08, 1.085e-08, 1.008e-08,
00647     9.224e-09, 8.389e-09, 7.262e-09, 6.278e-09, 5.335e-09, 4.388e-09,
00648     3.589e-09, 2.761e-09, 2.129e-09, 1.633e-09, 1.243e-09, 9.681e-10,
00649     8.355e-10, 7.665e-10, 7.442e-10, 8.584e-10, 9.732e-10, 1.063e-09,
00650     1.163e-09, 1.286e-09, 1.472e-09, 1.707e-09, 2.032e-09, 2.474e-09,
00651     2.977e-09, 3.506e-09, 4.102e-09, 5.013e-09, 6.493e-09, 8.414e-09,
00652     1.077e-08, 1.367e-08, 1.777e-08, 2.625e-08, 3.926e-08, 5.545e-08,
00653     7.195e-08, 9.464e-08, 1.404e-07, 2.183e-07, 3.329e-07, 4.535e-07,
00654     6.158e-07, 8.187e-07, 1.075e-06, 1.422e-06, 1.979e-06, 2.71e-06,
00655     3.58e-06, 4.573e-06, 5.951e-06, 7.999e-06, 1.072e-05, 1.372e-05,
00656     1.697e-05, 2.112e-05, 2.643e-05, 3.288e-05, 3.994e-05, 4.794e-05,
00657     5.606e-05, 6.383e-05, 7.286e-05, 8.156e-05, 8.883e-05, 9.469e-05,
00658     9.848e-05, 0.0001023, 0.0001066, 0.0001115, 0.0001145, 0.0001142,
00659     0.0001133
00660   };
00661
00662   static double no2[121] = {
00663     3.036e-09, 2.945e-10, 9.982e-11, 5.069e-11, 3.485e-11, 2.982e-11,
00664     2.947e-11, 3.164e-11, 3.714e-11, 4.586e-11, 6.164e-11, 8.041e-11,
00665     9.982e-11, 1.283e-10, 1.73e-10, 2.56e-10, 3.909e-10, 5.959e-10,
00666     9.081e-10, 1.384e-09, 1.788e-09, 2.189e-09, 2.686e-09, 3.091e-09,
00667     3.49e-09, 3.796e-09, 4.2e-09, 5.103e-09, 6.005e-09, 6.3e-09, 6.706e-09,
00668     7.07e-09, 7.434e-09, 7.663e-09, 7.788e-09, 7.8e-09, 7.597e-09,
00669     7.482e-09, 7.227e-09, 6.403e-09, 5.585e-09, 4.606e-09, 3.703e-09,
00670     2.984e-09, 2.183e-09, 1.48e-09, 8.441e-10, 5.994e-10, 3.799e-10,
00671     2.751e-10, 1.927e-10, 1.507e-10, 1.102e-10, 6.971e-11, 5.839e-11,
00672     3.904e-11, 3.087e-11, 2.176e-11, 1.464e-11, 1.209e-11, 8.497e-12,
00673     6.477e-12, 4.371e-12, 2.914e-12, 2.424e-12, 1.753e-12, 1.35e-12,
00674     9.417e-13, 6.622e-13, 5.148e-13, 3.841e-13, 3.446e-13, 3.01e-13,
00675     2.551e-13, 2.151e-13, 1.829e-13, 1.64e-13, 1.475e-13, 1.352e-13,
00676     1.155e-13, 9.963e-14, 9.771e-14, 9.577e-14, 9.384e-14, 9.186e-14,
00677     9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14,
00678     9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14,
00679     9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14,
00680     9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14
00681   };
00682
00683   static double o3[121] = {
00684     2.218e-08, 3.394e-08, 3.869e-08, 4.219e-08, 4.501e-08, 4.778e-08,
00685     5.067e-08, 5.402e-08, 5.872e-08, 6.521e-08, 7.709e-08, 9.461e-08,
00686     1.269e-07, 1.853e-07, 2.723e-07, 3.964e-07, 5.773e-07, 8.2e-07,
00687     1.155e-06, 1.59e-06, 2.076e-06, 2.706e-06, 3.249e-06, 3.848e-06,
00688     4.459e-06, 4.986e-06, 5.573e-06, 5.958e-06, 6.328e-06, 6.661e-06,
00689     6.9e-06, 7.146e-06, 7.276e-06, 7.374e-06, 7.447e-06, 7.383e-06,
00690     7.321e-06, 7.161e-06, 6.879e-06, 6.611e-06, 6.216e-06, 5.765e-06,
00691     5.355e-06, 4.905e-06, 4.471e-06, 4.075e-06, 3.728e-06, 3.413e-06,
00692     3.125e-06, 2.856e-06, 2.607e-06, 2.379e-06, 2.17e-06, 1.978e-06,
00693     1.8e-06, 1.646e-06, 1.506e-06, 1.376e-06, 1.233e-06, 1.102e-06,
00694     9.839e-07, 8.771e-07, 7.814e-07, 6.947e-07, 6.102e-07, 5.228e-07,
00695     4.509e-07, 3.922e-07, 3.501e-07, 3.183e-07, 2.909e-07, 2.686e-07,
00696     2.476e-07, 2.284e-07, 2.109e-07, 2.003e-07, 2.013e-07, 2.022e-07,
00697     2.032e-07, 2.042e-07, 2.097e-07, 2.361e-07, 2.656e-07, 2.989e-07,
00698     3.37e-07, 3.826e-07, 4.489e-07, 5.26e-07, 6.189e-07, 7.312e-07,
00699     8.496e-07, 8.444e-07, 8.392e-07, 8.339e-07, 8.286e-07, 8.234e-07,
00700     8.181e-07, 8.129e-07, 8.077e-07, 8.026e-07, 6.918e-07, 5.176e-07,
00701     3.865e-07, 2.885e-07, 2.156e-07, 1.619e-07, 1.219e-07, 9.161e-08,
00702     6.972e-08, 5.399e-08, 3.498e-08, 2.111e-08, 1.322e-08, 8.482e-09,
00703     5.527e-09, 3.423e-09, 2.071e-09, 1.314e-09, 8.529e-10, 5.503e-10,
00704     3.665e-10
00705   };
00706
00707   static double ocs[121] = {
00708     6e-10, 6e-10, 6e-10, 6e-10, 6e-10, 6e-10, 6e-10, 6e-10, 6e-10, 5.997e-10,
00709     5.989e-10, 5.881e-10, 5.765e-10, 5.433e-10, 5.074e-10, 4.567e-10,
00710     4.067e-10, 3.601e-10, 3.093e-10, 2.619e-10, 2.232e-10, 1.805e-10,
00711     1.46e-10, 1.187e-10, 8.03e-11, 5.435e-11, 3.686e-11, 2.217e-11,
00712     1.341e-11, 8.756e-12, 4.511e-12, 2.37e-12, 1.264e-12, 8.28e-13,
00713     5.263e-13, 3.209e-13, 1.717e-13, 9.068e-14, 4.709e-14, 2.389e-14,
00714     1.236e-14, 1.127e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14,
00715     1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14,
00716     1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14,
00717     1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14,
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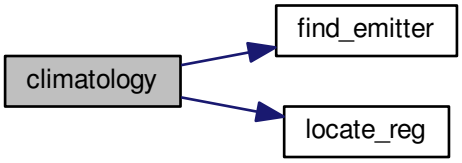
00718     1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14,
00719     1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14,
00720     1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14,
00721     1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14,
00722     1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14,
00723     1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14,
00724     1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14,
00725     1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14,
00726     1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14,
00727     1.091e-14, 1.091e-14, 1.091e-14
00728   };
00729
00730   static double sf6[121] = {
00731     4.103e-12, 4.103e-12, 4.103e-12, 4.103e-12, 4.103e-12, 4.103e-12,
00732     4.103e-12, 4.103e-12, 4.103e-12, 4.087e-12, 4.064e-12, 4.023e-12,
00733     3.988e-12, 3.941e-12, 3.884e-12, 3.755e-12, 3.622e-12, 3.484e-12,
00734     3.32e-12, 3.144e-12, 2.978e-12, 2.811e-12, 2.653e-12, 2.489e-12,
00735     2.332e-12, 2.199e-12, 2.089e-12, 2.013e-12, 1.953e-12, 1.898e-12,
00736     1.859e-12, 1.826e-12, 1.798e-12, 1.776e-12, 1.757e-12, 1.742e-12,
00737     1.728e-12, 1.717e-12, 1.707e-12, 1.698e-12, 1.691e-12, 1.685e-12,
00738     1.679e-12, 1.675e-12, 1.671e-12, 1.668e-12, 1.665e-12, 1.663e-12,
00739     1.661e-12, 1.659e-12, 1.658e-12, 1.657e-12, 1.656e-12, 1.655e-12,
00740     1.654e-12, 1.653e-12, 1.653e-12, 1.652e-12, 1.652e-12, 1.652e-12,
00741     1.651e-12, 1.651e-12, 1.651e-12, 1.651e-12, 1.651e-12, 1.651e-12,
00742     1.651e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12,
00743     1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12,
00744     1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12,
00745     1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12,
00746     1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12,
00747     1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12,
00748     1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12,
00749     1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12
00750   };
00751
00752   static double so2[121] = {
00753     1e-10, 1e-10, 1e-10, 1e-10, 1e-10, 1e-10, 1e-10, 1e-10, 1e-10, 1e-10,
00754     1e-10, 1e-10, 9.867e-11, 9.537e-11, 9e-11, 8.404e-11, 7.799e-11,
00755     7.205e-11, 6.616e-11, 6.036e-11, 5.475e-11, 5.007e-11, 4.638e-11,
00756     4.346e-11, 4.055e-11, 3.763e-11, 3.471e-11, 3.186e-11, 2.905e-11,
00757     2.631e-11, 2.358e-11, 2.415e-11, 2.949e-11, 3.952e-11, 5.155e-11,
00758     6.76e-11, 8.741e-11, 1.099e-10, 1.278e-10, 1.414e-10, 1.512e-10,
00759     1.607e-10, 1.699e-10, 1.774e-10, 1.832e-10, 1.871e-10, 1.907e-10,
00760     1.943e-10, 1.974e-10, 1.993e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10,
00761     2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10,
00762     2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10,
00763     2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10,
00764     2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10,
00765     2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10,
00766     2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10,
00767     2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10
00768   };
00769
00770   static int ig_co2 = -999;
00771
00772   double co2, *q[NG] = { NULL };
00773
00774   int ig, ip, iw, iz;
00775
00776   /* Find emitter index of CO2... */
00777   if (ig_co2 == -999)
00778     ig_co2 = find_emitter(ctl, "CO2");
00779
00780   /* Identify variable... */
00781   for (ig = 0; ig < ctl->ng; ig++) {
00782     q[ig] = NULL;
00783     if (strcasecmp(ctl->emitter[ig], "C2H2") == 0)
00784       q[ig] = c2h2;
00785     if (strcasecmp(ctl->emitter[ig], "C2H6") == 0)
00786       q[ig] = c2h6;
00787     if (strcasecmp(ctl->emitter[ig], "CCl4") == 0)
00788       q[ig] = ccl4;
00789     if (strcasecmp(ctl->emitter[ig], "CH4") == 0)
00790       q[ig] = ch4;
00791     if (strcasecmp(ctl->emitter[ig], "ClO") == 0)
00792       q[ig] = clo;
00793     if (strcasecmp(ctl->emitter[ig], "ClONO2") == 0)
00794       q[ig] = clono2;
00795     if (strcasecmp(ctl->emitter[ig], "CO") == 0)
00796       q[ig] = co;
00797     if (strcasecmp(ctl->emitter[ig], "COF2") == 0)
00798       q[ig] = cof2;
00799     if (strcasecmp(ctl->emitter[ig], "F11") == 0)
00800       q[ig] = f11;
00801     if (strcasecmp(ctl->emitter[ig], "F12") == 0)
00802       q[ig] = f12;
00803     if (strcasecmp(ctl->emitter[ig], "F14") == 0)
00804       q[ig] = f14;
```

```
00805     if (strcasecmp(ctl->emitter[ig], "F22") == 0)
00806       q[ig] = f22;
00807     if (strcasecmp(ctl->emitter[ig], "H2O") == 0)
00808       q[ig] = h2o;
00809     if (strcasecmp(ctl->emitter[ig], "H2O2") == 0)
00810       q[ig] = h2o2;
00811     if (strcasecmp(ctl->emitter[ig], "HCN") == 0)
00812       q[ig] = hcn;
00813     if (strcasecmp(ctl->emitter[ig], "HNO3") == 0)
00814       q[ig] = hno3;
00815     if (strcasecmp(ctl->emitter[ig], "HNO4") == 0)
00816       q[ig] = hno4;
00817     if (strcasecmp(ctl->emitter[ig], "HOCl") == 0)
00818       q[ig] = hocl;
00819     if (strcasecmp(ctl->emitter[ig], "N2O") == 0)
00820       q[ig] = n2o;
00821     if (strcasecmp(ctl->emitter[ig], "N2O5") == 0)
00822       q[ig] = n2o5;
00823     if (strcasecmp(ctl->emitter[ig], "NH3") == 0)
00824       q[ig] = nh3;
00825     if (strcasecmp(ctl->emitter[ig], "NO") == 0)
00826       q[ig] = no;
00827     if (strcasecmp(ctl->emitter[ig], "NO2") == 0)
00828       q[ig] = no2;
00829     if (strcasecmp(ctl->emitter[ig], "O3") == 0)
00830       q[ig] = o3;
00831     if (strcasecmp(ctl->emitter[ig], "OCS") == 0)
00832       q[ig] = ocs;
00833     if (strcasecmp(ctl->emitter[ig], "SF6") == 0)
00834       q[ig] = sf6;
00835     if (strcasecmp(ctl->emitter[ig], "SO2") == 0)
00836       q[ig] = so2;
00837   }
00838
00839   /* Loop over atmospheric data points... */
00840   for (ip = 0; ip < atm->np; ip++) {
00841
00842     /* Get altitude index... */
00843     iz = locate_reg(z, 121, atm->z[ip]);
00844
00845     /* Interpolate pressure... */
00846     atm->p[ip] = EXP(z[iz], pre[iz], z[iz + 1], pre[iz + 1], atm->z[ip]);
00847
00848     /* Interpolate temperature... */
00849     atm->t[ip] = LIN(z[iz], tem[iz], z[iz + 1], tem[iz + 1], atm->z[ip]);
00850
00851     /* Interpolate trace gases... */
00852     for (ig = 0; ig < ctl->ng; ig++)
00853       if (q[ig] != NULL)
00854         atm->q[ig][ip] =
00855           LIN(z[iz], q[ig][iz], z[iz + 1], q[ig][iz + 1], atm->z[ip]);
00856       else
00857         atm->q[ig][ip] = 0;
00858
00859     /* Set CO2... */
00860     if (ig_co2 >= 0) {
00861       co2 =
00862         371.789948e-6 + 2.026214e-6 * (atm->time[ip] - 63158400.) / 31557600.;
00863       atm->q[ig_co2][ip] = co2;
00864     }
00865
00866     /* Set extinction to zero... */
00867     for (iw = 0; iw < ctl->nw; iw++)
00868       atm->k[iw][ip] = 0;
00869   }
00870 }
```

Here is the call graph for this function:



5.13.2.6 double ctmco2 (double *nu*, double *p*, double *t*, double *u*)

Compute carbon dioxide continuum (optical depth).

Definition at line 874 of file jurassic.c.

```
00878             {
00879
00880   static double co2296[2001] = { 9.3388e-5, 9.7711e-5, 1.0224e-4, 1.0697e-4,
00881     1.1193e-4, 1.1712e-4, 1.2255e-4, 1.2824e-4, 1.3419e-4, 1.4043e-4,
00882     1.4695e-4, 1.5378e-4, 1.6094e-4, 1.6842e-4, 1.7626e-4, 1.8447e-4,
00883     1.9307e-4, 2.0207e-4, 2.1149e-4, 2.2136e-4, 2.3169e-4, 2.4251e-4,
00884     2.5384e-4, 2.657e-4, 2.7813e-4, 2.9114e-4, 3.0477e-4, 3.1904e-4,
00885     3.3399e-4, 3.4965e-4, 3.6604e-4, 3.8322e-4, 4.0121e-4, 4.2006e-4,
00886     4.398e-4, 4.6047e-4, 4.8214e-4, 5.0483e-4, 5.286e-4, 5.535e-4,
00887     5.7959e-4, 6.0693e-4, 6.3557e-4, 6.6558e-4, 6.9702e-4, 7.2996e-4,
00888     7.6449e-4, 8.0066e-4, 8.3856e-4, 8.7829e-4, 9.1991e-4, 9.6354e-4,
00889     .0010093, .0010572, .0011074, .00116, .0012152, .001273,
00890     .0013336, .0013972, .0014638, .0015336, .0016068, .0016835,
00891     .001764, .0018483, .0019367, .0020295, .0021267, .0022286,
00892     .0023355, .0024476, .0025652, .0026885, .0028178, .0029534,
00893     .0030956, .0032448, .0034012, .0035654, .0037375, .0039181,
00894     .0041076, .0043063, .0045148, .0047336, .0049632, .005204,
00895     .0054567, .0057219, .0060002, .0062923, .0065988, .0069204,
00896     .007258, .0076123, .0079842, .0083746, .0087844, .0092146,
00897     .0096663, .01014, .010638, .011161, .01171, .012286, .012891,
00898     .013527, .014194, .014895, .015631, .016404, .017217, .01807,
00899     .018966, .019908, .020897, .021936, .023028, .024176, .025382,
00900     .026649, .027981, .02938, .030851, .032397, .034023, .035732,
00901     .037528, .039416, .041402, .04349, .045685, .047994, .050422,
00902     .052975, .055661, .058486, .061458, .064584, .067873, .071334,
00903     .074975, .078807, .082839, .087082, .091549, .096249, .1012,
00904     .10641, .11189, .11767, .12375, .13015, .13689, .14399, .15147,
00905     .15935, .16765, .17639, .18561, .19531, .20554, .21632, .22769,
00906     .23967, .25229, .2656, .27964, .29443, .31004, .3265, .34386,
00907     .36218, .3815, .40188, .42339, .44609, .47004, .49533, .52202,
00908     .5502, .57995, .61137, .64455, .6796, .71663, .75574, .79707,
00909     .84075, .88691, .9357, .98728, 1.0418, 1.0995, 1.1605, 1.225,
00910     1.2932, 1.3654, 1.4418, 1.5227, 1.6083, 1.6989, 1.7948, 1.8964,
00911     2.004, 2.118, 2.2388, 2.3668, 2.5025, 2.6463, 2.7988, 2.9606,
00912     3.1321, 3.314, 3.5071, 3.712, 3.9296, 4.1605, 4.4058, 4.6663,
00913     4.9431, 5.2374, 5.5501, 5.8818, 6.2353, 6.6114, 7.0115, 7.4372,
00914     7.8905, 8.3731, 8.8871, 9.4349, 10.019, 10.641, 11.305, 12.013,
00915     12.769, 13.576, 14.437, 15.358, 16.342, 17.39, 18.513, 19.716,
00916     21.003, 22.379, 23.854, 25.436, 27.126, 28.942, 30.89, 32.973,
00917     35.219, 37.634, 40.224, 43.021, 46.037, 49.29, 52.803, 56.447,
00918     60.418, 64.792, 69.526, 74.637, 80.182, 86.193, 92.713, 99.786,
00919     107.47, 115.84, 124.94, 134.86, 145.69, 157.49, 170.3, 184.39,
00920     199.83, 216.4, 234.55, 254.72, 276.82, 299.85, 326.16, 354.99,
00921     386.51, 416.68, 449.89, 490.12, 534.35, 578.25, 632.26, 692.61,
00922     756.43, 834.75, 924.11, 1016.9, 996.96, 1102.7, 1219.2, 1351.9,
00923     1494.3, 1654.1, 1826.5, 2027.9, 2249., 2453.8, 2714.4, 2999.4,
00924     3209.5, 3509., 3840.4, 3907.5, 4190.7, 4533.5, 4648.3, 5059.1,
00925     5561.6, 6191.4, 6820.8, 7905.9, 9362.2, 2431.3, 2211.3, 2046.8,
00926     2023.8, 1985.9, 1905.9, 1491.1, 1369.8, 1262.2, 1200.7, 887.74,
00927     820.25, 885.23, 887.21, 816.73, 1126.9, 1216.2, 1272.4, 1579.5,
00928     1634.2, 1656.3, 1657.9, 1789.5, 1670.8, 1509.5, 8474.6, 7489.2,
00929     6793.6, 6117., 5574.1, 5141.2, 5084.6, 4745.1, 4413.2, 4102.8,
```

```
00930     4024.7, 3715., 3398.6, 3100.8, 2900.4, 2629.2, 2374., 2144.7,
00931     1955.8, 1760.8, 1591.2, 1435.2, 1296.2, 1174., 1065.1, 967.76,
00932     999.48, 897.45, 809.23, 732.77, 670.26, 611.93, 560.11, 518.77,
00933     476.84, 438.8, 408.48, 380.21, 349.24, 322.71, 296.65, 272.85,
00934     251.96, 232.04, 213.88, 197.69, 182.41, 168.41, 155.79, 144.05,
00935     133.31, 123.48, 114.5, 106.21, 98.591, 91.612, 85.156, 79.204,
00936     73.719, 68.666, 63.975, 59.637, 56.35, 52.545, 49.042, 45.788,
00937     42.78, 39.992, 37.441, 35.037, 32.8, 30.744, 28.801, 26.986,
00938     25.297, 23.731, 22.258, 20.883, 19.603, 18.403, 17.295, 16.249,
00939     15.271, 14.356, 13.501, 12.701, 11.954, 11.254, 10.6, 9.9864,
00940     9.4118, 8.8745, 8.3714, 7.8997, 7.4578, 7.0446, 6.6573, 6.2949,
00941     5.9577, 5.6395, 5.3419, 5.063, 4.8037, 4.5608, 4.3452, 4.1364,
00942     3.9413, 3.7394, 3.562, 3.3932, 3.2325, 3.0789, 2.9318, 2.7898,
00943     2.6537, 2.5225, 2.3958, 2.2305, 2.1215, 2.0245, 1.9427, 1.8795,
00944     1.8336, 1.7604, 1.7016, 1.6419, 1.5282, 1.4611, 1.3443, 1.27,
00945     1.1675, 1.0824, 1.0534, .99833, .95854, .92981, .90887, .89346,
00946     .88113, .87068, .86102, .85096, .88262, .86151, .83565, .80518,
00947     .77045, .73736, .74744, .74954, .75773, .82267, .83493, .89402,
00948     .89725, .93426, .95564, .94045, .94174, .93404, .92035, .90456,
00949     .88621, .86673, .78117, .7515, .72056, .68822, .65658, .62764,
00950     .55984, .55598, .57407, .60963, .63763, .66198, .61132, .60972,
00951     .52496, .50649, .41872, .3964, .32422, .27276, .24048, .23772,
00952     .2286, .22711, .23999, .32038, .34371, .36621, .38561, .39953,
00953     .40636, .44913, .42716, .3919, .35477, .33935, .3351, .39746,
00954     .40993, .49398, .49956, .56157, .54742, .57295, .57386, .55417,
00955     .50745, .471, .43446, .39102, .34993, .31269, .27888, .24912,
00956     .22291, .19994, .17972, .16197, .14633, .13252, .12029, .10942,
00957     .099745, .091118, .083404, .076494, .070292, .064716, .059697,
00958     .055173, .051093, .047411, .044089, .041092, .038392, .035965,
00959     .033789, .031846, .030122, .028607, .02729, .026169, .025209,
00960     .024405, .023766, .023288, .022925, .022716, .022681, .022685,
00961     .022768, .023133, .023325, .023486, .024004, .024126, .024083,
00962     .023785, .024023, .023029, .021649, .021108, .019454, .017809,
00963     .017292, .016635, .017037, .018068, .018977, .018756, .017847,
00964     .016557, .016142, .014459, .012869, .012381, .010875, .0098701,
00965     .009285, .0091698, .0091701, .0096145, .010553, .01106, .012613,
00966     .014362, .015017, .016507, .017741, .01768, .017784, .0171,
00967     .016357, .016172, .017257, .018978, .020935, .021741, .023567,
00968     .025183, .025589, .026732, .027648, .028278, .028215, .02856,
00969     .029015, .029062, .028851, .028497, .027825, .027801, .026523,
00970     .02487, .022967, .022168, .020194, .018605, .017903, .018439,
00971     .019697, .020311, .020855, .020057, .018608, .016738, .015963,
00972     .013844, .011801, .011134, .0097573, .0086007, .0086226,
00973     .0083721, .0090978, .0097616, .0098426, .011317, .012853, .01447,
00974     .014657, .015771, .016351, .016079, .014829, .013431, .013185,
00975     .013207, .01448, .016176, .017971, .018265, .019526, .020455,
00976     .019797, .019802, .0194, .018176, .017505, .016197, .015339,
00977     .014401, .013213, .012203, .011186, .010236, .0093288, .0084854,
00978     .0076837, .0069375, .0062614, .0056628, .0051153, .0046015,
00979     .0041501, .003752, .0033996, .0030865, .0028077, .0025586,
00980     .0023355, .0021353, .0019553, .0017931, .0016466, .0015141,
00981     .0013941, .0012852, .0011862, .0010962, .0010142, 9.3935e-4,
00982     8.71e-4, 8.0851e-4, 7.5132e-4, 6.9894e-4, 6.5093e-4, 6.0689e-4,
00983     5.6647e-4, 5.2935e-4, 4.9525e-4, 4.6391e-4, 4.3509e-4, 4.086e-4,
00984     3.8424e-4, 3.6185e-4, 3.4126e-4, 3.2235e-4, 3.0498e-4, 2.8904e-4,
00985     2.7444e-4, 2.6106e-4, 2.4883e-4, 2.3766e-4, 2.275e-4, 2.1827e-4,
00986     2.0992e-4, 2.0239e-4, 1.9563e-4, 1.896e-4, 1.8427e-4, 1.796e-4,
00987     1.7555e-4, 1.7209e-4, 1.692e-4, 1.6687e-4, 1.6505e-4, 1.6375e-4,
00988     1.6294e-4, 1.6261e-4, 1.6274e-4, 1.6334e-4, 1.6438e-4, 1.6587e-4,
00989     1.678e-4, 1.7017e-4, 1.7297e-4, 1.762e-4, 1.7988e-4, 1.8399e-4,
00990     1.8855e-4, 1.9355e-4, 1.9902e-4, 2.0494e-4, 2.1134e-4, 2.1823e-4,
00991     2.2561e-4, 2.335e-4, 2.4192e-4, 2.5088e-4, 2.604e-4, 2.705e-4,
00992     2.8119e-4, 2.9251e-4, 3.0447e-4, 3.171e-4, 3.3042e-4, 3.4447e-4,
00993     3.5927e-4, 3.7486e-4, 3.9127e-4, 4.0854e-4, 4.267e-4, 4.4579e-4,
00994     4.6586e-4, 4.8696e-4, 5.0912e-4, 5.324e-4, 5.5685e-4, 5.8253e-4,
00995     6.0949e-4, 6.378e-4, 6.6753e-4, 6.9873e-4, 7.3149e-4, 7.6588e-4,
00996     8.0198e-4, 8.3987e-4, 8.7964e-4, 9.2139e-4, 9.6522e-4, .0010112,
00997     .0010595, .0011102, .0011634, .0012193, .001278, .0013396,
00998     .0014043, .0014722, .0015436, .0016185, .0016972, .0017799,
00999     .0018668, .001958, .0020539, .0021547, .0022606, .0023719,
01000     .002489, .002612, .0027414, .0028775, .0030206, .0031712,
01001     .0033295, .0034962, .0036716, .0038563, .0040506, .0042553,
01002     .0044709, .004698, .0049373, .0051894, .0054552, .0057354,
01003     .006031, .0063427, .0066717, .0070188, .0073854, .0077726,
01004     .0081816, .0086138, .0090709, .0095543, .010066, .010607,
01005     .011181, .011789, .012433, .013116, .013842, .014613, .015432,
01006     .016304, .017233, .018224, .019281, .020394, .021574, .022836,
01007     .024181, .025594, .027088, .028707, .030401, .032245, .034219,
01008     .036262, .038539, .040987, .043578, .04641, .04949, .052726,
01009     .056326, .0602, .064093, .068521, .073278, .077734, .083064,
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01634     .0030785, .002928, .0027851, .0026492, .0025201, .0023975,
01635     .0022809, .0021701, .0020649, .0019649, .0018699, .0017796,
01636     .0016938, .0016122, .0015348, .0014612, .0013913, .001325,
01637     .0012619, .0012021, .0011452, .0010913, .0010401, 9.9149e-4,
01638     9.454e-4, 9.0169e-4, 8.6024e-4, 8.2097e-4, 7.8377e-4, 7.4854e-4,
01639     7.1522e-4, 6.8371e-4, 6.5393e-4, 6.2582e-4, 5.9932e-4, 5.7435e-4,
01640     5.5087e-4, 5.2882e-4, 5.0814e-4, 4.8881e-4, 4.7076e-4, 4.5398e-4,
01641     4.3843e-4, 4.2407e-4, 4.109e-4, 3.9888e-4, 3.88e-4, 3.7826e-4,
01642     3.6963e-4, 3.6213e-4, 3.5575e-4, 3.505e-4, 3.464e-4, 3.4346e-4,
01643     3.4173e-4, 3.4125e-4, 3.4206e-4, 3.4424e-4, 3.4787e-4, 3.5303e-4,
01644     3.5986e-4, 3.6847e-4, 3.7903e-4, 3.9174e-4, 4.0681e-4, 4.2455e-4,
01645     4.4527e-4, 4.6942e-4, 4.9637e-4, 5.2698e-4, 5.5808e-4, 5.9514e-4,
01646     6.2757e-4, 6.689e-4, 7.1298e-4, 7.3955e-4, 7.8403e-4, 8.0449e-4,
01647     8.5131e-4, 9.0256e-4, 9.3692e-4, .0010051, .0010846, .0011678,
01648     .001282, .0014016, .0015355, .0016764, .0018272, .0020055,
01649     .0021455, .0023421, .0024615, .0026786, .0028787, .0031259,
01650     .0034046, .0036985, .0040917, .0043902, .0048349, .0049531,
01651     .0052989, .0056148, .0052452, .0053357, .005333, .0045069,
01652     .0043851, .004253, .003738, .0038084, .0039013, .0041505,
01653     .0045372, .0050569, .0054507, .0061267, .0066122, .0072449,
01654     .0078012, .0082651, .0076538, .0076573, .0076806, .0075227,
01655     .0076269, .0063758, .006254, .0067749, .0067909, .0068231,
01656     .0072143, .0072762, .0072954, .007679, .0075107, .0073658,
01657     .0072441, .0071074, .0070378, .007176, .0072472, .0075844,
01658     .0079291, .008412, .0090165, .010688, .011535, .012375, .013166,
01659     .013895, .015567, .016011, .016392, .016737, .017043, .017731,
01660     .018031, .018419, .018877, .019474, .019868, .020604, .021538,
01661     .022653, .023869, .025288, .026879, .028547, .030524, .03274,
01662     .035132, .03769, .040567, .043793, .047188, .049962, .053542,
01663     .057205, .060776, .061489, .064419, .067124, .065945, .068487,
01664     .071209, .074783, .077039, .082444, .08902, .09692, .10617,
01665     .11687, .12952, .12362, .13498, .14412, .15492, .16519, .1744,
01666     .17096, .17714, .18208, .17363, .17813, .18564, .18295, .19045,
01667     .20252, .20815, .21844, .22929, .24229, .25321, .26588, .2797,
01668     .29465, .31136, .32961, .36529, .38486, .41027, .43694, .4667,
01669     .49943, .54542, .58348, .62303, .67633, .71755, .76054, .81371,
01670     .85934, .90841, .96438, 1.0207, 1.0821, 1.1491, 1.2226, 1.3018,
01671     1.388, 1.4818, 1.5835, 1.6939, 1.8137, 1.9435, 2.0843, 2.237,
01672     2.4026, 2.5818, 2.7767, 2.9885, 3.2182, 3.4679, 3.7391, 4.0349,
01673     4.3554, 4.7053, 5.0849, 5.4986, 5.9436, 6.4294, 6.9598, 7.5203,
01674     8.143, 8.8253, 9.5568, 10.371, 11.267, 12.233, 13.31, 14.357,
01675     15.598, 16.93, 18.358, 19.849, 21.408, 23.04, 24.706, 26.409,
01676     28.153, 28.795, 30.549, 32.43, 34.49, 36.027, 38.955, 42.465,
01677     46.565, 50.875, 55.378, 59.002, 63.882, 67.949, 73.693, 80.095,
01678     86.403, 94.264, 102.65, 112.37, 123.3, 135.54, 149.14, 163.83,
01679     179.17, 196.89, 217.91, 240.94, 264.13, 292.39, 324.83, 358.21,
01680     397.16, 440.5, 488.6, 541.04, 595.3, 650.43, 652.03, 688.74,
01681     719.47, 743.54, 757.68, 762.35, 756.43, 741.42, 595.43, 580.97,
01682     580.83, 605.68, 667.88, 764.49, 759.93, 789.12, 798.17, 645.66,
01683     615.65, 455.05, 421.09, 306.45, 289.14, 235.7, 215.52, 274.57,
01684     316.53, 357.73, 409.89, 465.06, 521.84, 579.02, 630.64, 794.46,
01685     813., 813.56, 796.25, 761.57, 727.97, 812.14, 866.75, 932.5,
01686     1132.8, 1194.8, 1362.2, 1387.2, 1482.3, 1479.7, 1517.9, 1533.1,
01687     1534.2, 1523.3, 1522.5, 1515.5, 1505.2, 1486.5, 1454., 1412.,
01688     1358.8, 1107.8, 1060.9, 1033.5, 1048.2, 1122.4, 1248.9, 1227.1,
01689     1255.4, 1058.9, 1020.7, 970.59, 715.24, 512.56, 468.47, 349.3,
01690     338.26, 299.22, 301.26, 332.38, 382.08, 445.49, 515.87, 590.85,
01691     662.3, 726.05, 955.59, 964.11, 945.17, 891.48, 807.11, 720.9,
01692     803.36, 834.46, 1073.9, 1107.1, 1123.6, 1296., 1393.7, 1303.1,
01693     1284.3, 1161.8, 1078.8, 976.13, 868.72, 767.4, 674.72, 593.73,
01694     523.12, 462.24, 409.75, 364.34, 325., 290.73, 260.76, 234.46,
01695     211.28, 190.78, 172.61, 156.44, 142.01, 129.12, 117.57, 107.2,
01696     97.877, 89.47, 81.882, 75.021, 68.807, 63.171, 58.052, 53.396,
01697     49.155, 45.288, 41.759, 38.531, 35.576, 32.868, 30.384, 28.102,
01698     26.003, 24.071, 22.293, 20.655, 19.147, 17.756, 16.476, 15.292,
01699     14.198, 13.183, 12.241, 11.367, 10.554, 9.7989, 9.0978, 8.4475,
01700     7.845, 7.2868, 6.7704, 6.2927, 5.8508, 5.4421, 5.064, 4.714,
01701     4.3902, 4.0902, 3.8121, 3.5543, 3.315, 3.093, 2.8869, 2.6953,
01702     2.5172, 2.3517, 2.1977, 2.0544, 1.9211, 1.7969, 1.6812, 1.5735,
01703     1.4731, 1.3794, 1.2921, 1.2107, 1.1346, 1.0637, .99744, .93554,
01704     .87771, .82368, .77313, .72587, .6816, .64014, .60134, .565,
01705     .53086, .49883, .46881, .44074, .4144, .38979, .36679, .34513,
01706     .32474, .30552, .28751, .27045, .25458, .23976, .22584, .21278,
01707     .20051, .18899, .17815, .16801, .15846, .14954, .14117, .13328,
01708     .12584
01709   };
01710
01711   double xw, dw, ew, cw296, cw260, cw230, dt230, dt260, dt296, ctw, ctmpth;
01712
```

```
01713   int iw;
01714
01715   /* Get CO2 continuum absorption... */
01716   xw = nu / 2 + 1;
01717   if (xw >= 1 && xw < 2001) {
01718     iw = (int) xw;
01719     dw = xw - iw;
01720     ew = 1 - dw;
01721     cw296 = ew * co2296[iw - 1] + dw * co2296[iw];
01722     cw260 = ew * co2260[iw - 1] + dw * co2260[iw];
01723     cw230 = ew * co2230[iw - 1] + dw * co2230[iw];
01724     dt230 = t - 230;
01725     dt260 = t - 260;
01726     dt296 = t - 296;
01727     ctw = dt260 * 5.050505e-4 * dt296 * cw230 - dt230 * 9.259259e-4
01728       * dt296 * cw260 + dt230 * 4.208754e-4 * dt260 * cw296;
01729     ctmpth = u / NA / 1000 * p / P0 * ctw;
01730   } else
01731     ctmpth = 0;
01732   return ctmpth;
01733 }
```

5.13.2.7 double ctmh2o (double *nu*, double *p*, double *t*, double *q*, double *u*)

Compute water vapor continuum (optical depth).

Definition at line 1737 of file jurassic.c.

```
01742             {
01743
01744   static double h2o296[2001] = { .17, .1695, .172, .168, .1687, .1624, .1606,
01745     .1508, .1447, .1344, .1214, .1133, .1009, .09217, .08297, .06989,
01746     .06513, .05469, .05056, .04417, .03779, .03484, .02994, .0272,
01747     .02325, .02063, .01818, .01592, .01405, .01251, .0108, .009647,
01748     .008424, .007519, .006555, .00588, .005136, .004511, .003989,
01749     .003509, .003114, .00274, .002446, .002144, .001895, .001676,
01750     .001486, .001312, .001164, .001031, 9.129e-4, 8.106e-4, 7.213e-4,
01751     6.4e-4, 5.687e-4, 5.063e-4, 4.511e-4, 4.029e-4, 3.596e-4,
01752     3.22e-4, 2.889e-4, 2.597e-4, 2.337e-4, 2.108e-4, 1.907e-4,
01753     1.728e-4, 1.57e-4, 1.43e-4, 1.305e-4, 1.195e-4, 1.097e-4,
01754     1.009e-4, 9.307e-5, 8.604e-5, 7.971e-5, 7.407e-5, 6.896e-5,
01755     6.433e-5, 6.013e-5, 5.631e-5, 5.283e-5, 4.963e-5, 4.669e-5,
01756     4.398e-5, 4.148e-5, 3.917e-5, 3.702e-5, 3.502e-5, 3.316e-5,
01757     3.142e-5, 2.978e-5, 2.825e-5, 2.681e-5, 2.546e-5, 2.419e-5,
01758     2.299e-5, 2.186e-5, 2.079e-5, 1.979e-5, 1.884e-5, 1.795e-5,
01759     1.711e-5, 1.633e-5, 1.559e-5, 1.49e-5, 1.426e-5, 1.367e-5,
01760     1.312e-5, 1.263e-5, 1.218e-5, 1.178e-5, 1.143e-5, 1.112e-5,
01761     1.088e-5, 1.07e-5, 1.057e-5, 1.05e-5, 1.051e-5, 1.059e-5,
01762     1.076e-5, 1.1e-5, 1.133e-5, 1.18e-5, 1.237e-5, 1.308e-5,
01763     1.393e-5, 1.483e-5, 1.614e-5, 1.758e-5, 1.93e-5, 2.123e-5,
01764     2.346e-5, 2.647e-5, 2.93e-5, 3.279e-5, 3.745e-5, 4.152e-5,
01765     4.813e-5, 5.477e-5, 6.203e-5, 7.331e-5, 8.056e-5, 9.882e-5,
01766     1.05e-4, 1.21e-4, 1.341e-4, 1.572e-4, 1.698e-4, 1.968e-4,
01767     2.175e-4, 2.431e-4, 2.735e-4, 2.867e-4, 3.19e-4, 3.371e-4,
01768     3.554e-4, 3.726e-4, 3.837e-4, 3.878e-4, 3.864e-4, 3.858e-4,
01769     3.841e-4, 3.852e-4, 3.815e-4, 3.762e-4, 3.618e-4, 3.579e-4,
01770     3.45e-4, 3.202e-4, 3.018e-4, 2.785e-4, 2.602e-4, 2.416e-4,
01771     2.097e-4, 1.939e-4, 1.689e-4, 1.498e-4, 1.308e-4, 1.17e-4,
01772     1.011e-4, 9.237e-5, 7.909e-5, 7.006e-5, 6.112e-5, 5.401e-5,
01773     4.914e-5, 4.266e-5, 3.963e-5, 3.316e-5, 3.037e-5, 2.598e-5,
01774     2.294e-5, 2.066e-5, 1.813e-5, 1.583e-5, 1.423e-5, 1.247e-5,
01775     1.116e-5, 9.76e-6, 8.596e-6, 7.72e-6, 6.825e-6, 6.108e-6,
01776     5.366e-6, 4.733e-6, 4.229e-6, 3.731e-6, 3.346e-6, 2.972e-6,
01777     2.628e-6, 2.356e-6, 2.102e-6, 1.878e-6, 1.678e-6, 1.507e-6,
01778     1.348e-6, 1.21e-6, 1.089e-6, 9.806e-7, 8.857e-7, 8.004e-7,
01779     7.261e-7, 6.599e-7, 6.005e-7, 5.479e-7, 5.011e-7, 4.595e-7,
01780     4.219e-7, 3.885e-7, 3.583e-7, 3.314e-7, 3.071e-7, 2.852e-7,
01781     2.654e-7, 2.474e-7, 2.311e-7, 2.162e-7, 2.026e-7, 1.902e-7,
01782     1.788e-7, 1.683e-7, 1.587e-7, 1.497e-7, 1.415e-7, 1.338e-7,
01783     1.266e-7, 1.2e-7, 1.138e-7, 1.08e-7, 1.027e-7, 9.764e-8,
01784     9.296e-8, 8.862e-8, 8.458e-8, 8.087e-8, 7.744e-8, 7.429e-8,
01785     7.145e-8, 6.893e-8, 6.664e-8, 6.468e-8, 6.322e-8, 6.162e-8,
01786     6.07e-8, 5.992e-8, 5.913e-8, 5.841e-8, 5.796e-8, 5.757e-8,
01787     5.746e-8, 5.731e-8, 5.679e-8, 5.577e-8, 5.671e-8, 5.656e-8,
01788     5.594e-8, 5.593e-8, 5.602e-8, 5.62e-8, 5.693e-8, 5.725e-8,
01789     5.858e-8, 6.037e-8, 6.249e-8, 6.535e-8, 6.899e-8, 7.356e-8,
01790     7.918e-8, 8.618e-8, 9.385e-8, 1.039e-7, 1.158e-7, 1.29e-7,
01791     1.437e-7, 1.65e-7, 1.871e-7, 2.121e-7, 2.427e-7, 2.773e-7,
01792     3.247e-7, 3.677e-7, 4.037e-7, 4.776e-7, 5.101e-7, 6.214e-7,
01793     6.936e-7, 7.581e-7, 8.486e-7, 9.355e-7, 9.942e-7, 1.063e-6,
```

```
01794     1.123e-6, 1.191e-6, 1.215e-6, 1.247e-6, 1.26e-6, 1.271e-6,
01795     1.284e-6, 1.317e-6, 1.323e-6, 1.349e-6, 1.353e-6, 1.362e-6,
01796     1.344e-6, 1.329e-6, 1.336e-6, 1.327e-6, 1.325e-6, 1.359e-6,
01797     1.374e-6, 1.415e-6, 1.462e-6, 1.526e-6, 1.619e-6, 1.735e-6,
01798     1.863e-6, 2.034e-6, 2.265e-6, 2.482e-6, 2.756e-6, 3.103e-6,
01799     3.466e-6, 3.832e-6, 4.378e-6, 4.913e-6, 5.651e-6, 6.311e-6,
01800     7.169e-6, 8.057e-6, 9.253e-6, 1.047e-5, 1.212e-5, 1.36e-5,
01801     1.569e-5, 1.776e-5, 2.02e-5, 2.281e-5, 2.683e-5, 2.994e-5,
01802     3.488e-5, 3.896e-5, 4.499e-5, 5.175e-5, 6.035e-5, 6.34e-5,
01803     7.281e-5, 7.923e-5, 8.348e-5, 9.631e-5, 1.044e-4, 1.102e-4,
01804     1.176e-4, 1.244e-4, 1.283e-4, 1.326e-4, 1.4e-4, 1.395e-4,
01805     1.387e-4, 1.363e-4, 1.314e-4, 1.241e-4, 1.228e-4, 1.148e-4,
01806     1.086e-4, 1.018e-4, 8.89e-5, 8.316e-5, 7.292e-5, 6.452e-5,
01807     5.625e-5, 5.045e-5, 4.38e-5, 3.762e-5, 3.29e-5, 2.836e-5,
01808     2.485e-5, 2.168e-5, 1.895e-5, 1.659e-5, 1.453e-5, 1.282e-5,
01809     1.132e-5, 1.001e-5, 8.836e-6, 7.804e-6, 6.922e-6, 6.116e-6,
01810     5.429e-6, 4.824e-6, 4.278e-6, 3.788e-6, 3.371e-6, 2.985e-6,
01811     2.649e-6, 2.357e-6, 2.09e-6, 1.858e-6, 1.647e-6, 1.462e-6,
01812     1.299e-6, 1.155e-6, 1.028e-6, 9.142e-7, 8.132e-7, 7.246e-7,
01813     6.451e-7, 5.764e-7, 5.151e-7, 4.603e-7, 4.121e-7, 3.694e-7,
01814     3.318e-7, 2.985e-7, 2.69e-7, 2.428e-7, 2.197e-7, 1.992e-7,
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01816     1.073e-7, 9.918e-8, 9.191e-8, 8.538e-8, 7.949e-8, 7.419e-8,
01817     6.94e-8, 6.508e-8, 6.114e-8, 5.761e-8, 5.437e-8, 5.146e-8,
01818     4.89e-8, 4.636e-8, 4.406e-8, 4.201e-8, 4.015e-8, 3.84e-8,
01819     3.661e-8, 3.51e-8, 3.377e-8, 3.242e-8, 3.13e-8, 3.015e-8,
01820     2.918e-8, 2.83e-8, 2.758e-8, 2.707e-8, 2.656e-8, 2.619e-8,
01821     2.609e-8, 2.615e-8, 2.63e-8, 2.675e-8, 2.745e-8, 2.842e-8,
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01823     4.59e-8, 5.059e-8, 5.607e-8, 6.239e-8, 6.958e-8, 7.796e-8,
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01825     1.822e-7, 2.06e-7, 2.337e-7, 2.645e-7, 2.996e-7, 3.393e-7,
01826     3.843e-7, 4.363e-7, 4.935e-7, 5.607e-7, 6.363e-7, 7.242e-7,
01827     8.23e-7, 9.411e-7, 1.071e-6, 1.232e-6, 1.402e-6, 1.6e-6, 1.82e-6,
01828     2.128e-6, 2.386e-6, 2.781e-6, 3.242e-6, 3.653e-6, 4.323e-6,
01829     4.747e-6, 5.321e-6, 5.919e-6, 6.681e-6, 7.101e-6, 7.983e-6,
01830     8.342e-6, 8.741e-6, 9.431e-6, 9.952e-6, 1.026e-5, 1.055e-5,
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01832     9.252e-6, 8.452e-6, 7.958e-6, 7.268e-6, 6.295e-6, 6.003e-6, 5e-6,
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01834     1.995e-6, 1.747e-6, 1.517e-6, 1.335e-6, 1.165e-6, 1.028e-6,
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01836     4.297e-7, 3.799e-7, 3.38e-7, 3.002e-7, 2.659e-7, 2.366e-7,
01837     2.103e-7, 1.861e-7, 1.655e-7, 1.469e-7, 1.309e-7, 1.162e-7,
01838     1.032e-7, 9.198e-8, 8.181e-8, 7.294e-8, 6.516e-8, 5.787e-8,
01839     5.163e-8, 4.612e-8, 4.119e-8, 3.695e-8, 3.308e-8, 2.976e-8,
01840     2.67e-8, 2.407e-8, 2.171e-8, 1.965e-8, 1.78e-8, 1.617e-8,
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02693     5.74e-11, 5.754e-11, 5.761e-11, 5.777e-11, 5.712e-11, 5.51e-11,
02694     5.088e-11, 4.438e-11, 3.728e-11, 2.994e-11, 2.305e-11, 1.715e-11,
02695     1.256e-11, 9.208e-12, 6.745e-12, 5.014e-12, 3.785e-12, 2.9e-12,
02696     2.239e-12, 1.757e-12, 1.414e-12, 1.142e-12, 9.482e-13, 8.01e-13,
02697     6.961e-13, 6.253e-13, 5.735e-13, 5.433e-13, 5.352e-13, 5.493e-13,
02698     5.706e-13, 6.068e-13, 6.531e-13, 7.109e-13, 7.767e-13, 8.59e-13,
02699     9.792e-13, 1.142e-12, 1.371e-12, 1.65e-12, 1.957e-12, 2.302e-12,
02700     2.705e-12, 3.145e-12, 3.608e-12, 4.071e-12, 4.602e-12, 5.133e-12,
02701     5.572e-12, 5.987e-12, 6.248e-12, 6.533e-12, 6.757e-12, 6.935e-12,
02702     7.224e-12, 7.422e-12, 7.538e-12, 7.547e-12, 7.495e-12, 7.543e-12,
02703     7.725e-12, 8.139e-12, 8.627e-12, 9.146e-12, 9.443e-12, 9.318e-12,
02704     8.649e-12, 7.512e-12, 6.261e-12, 4.915e-12, 3.647e-12, 2.597e-12,
02705     1.785e-12, 1.242e-12, 8.66e-13, 6.207e-13, 4.61e-13, 3.444e-13,
02706     2.634e-13, 2.1e-13, 1.725e-13, 1.455e-13, 1.237e-13, 1.085e-13,
02707     9.513e-14, 7.978e-14, 6.603e-14, 5.288e-14, 4.084e-14, 2.952e-14,
02708     2.157e-14, 1.593e-14, 1.199e-14, 9.267e-15, 7.365e-15, 6.004e-15,
02709     4.995e-15, 4.218e-15, 3.601e-15, 3.101e-15, 2.692e-15, 2.36e-15,
02710     2.094e-15, 1.891e-15, 1.755e-15, 1.699e-15, 1.755e-15, 1.987e-15,
02711     2.506e-15, 3.506e-15, 5.289e-15, 8.311e-15, 1.325e-14, 2.129e-14,
02712     3.237e-14, 4.595e-14, 6.441e-14, 8.433e-14, 1.074e-13, 1.383e-13,
02713     1.762e-13, 2.281e-13, 2.831e-13, 3.523e-13, 4.38e-13, 5.304e-13,
02714     6.29e-13, 7.142e-13, 8.032e-13, 8.934e-13, 9.888e-13, 1.109e-12,
02715     1.261e-12, 1.462e-12, 1.74e-12, 2.099e-12, 2.535e-12, 3.008e-12,
02716     3.462e-12, 3.856e-12, 4.098e-12, 4.239e-12, 4.234e-12, 4.132e-12,
02717     3.986e-12, 3.866e-12, 3.829e-12, 3.742e-12, 3.705e-12, 3.694e-12,
02718     3.765e-12, 3.849e-12, 3.929e-12, 4.056e-12, 4.092e-12, 4.047e-12,
02719     3.792e-12, 3.407e-12, 2.953e-12, 2.429e-12, 1.931e-12, 1.46e-12,
02720     1.099e-12, 8.199e-13, 6.077e-13, 4.449e-13, 3.359e-13, 2.524e-13,
02721     1.881e-13, 1.391e-13, 1.02e-13, 7.544e-14, 5.555e-14, 4.22e-14,
02722     3.321e-14, 2.686e-14, 2.212e-14, 1.78e-14, 1.369e-14, 1.094e-14,
02723     9.13e-15, 8.101e-15, 7.828e-15, 8.393e-15, 1.012e-14, 1.259e-14,
02724     1.538e-14, 1.961e-14, 2.619e-14, 3.679e-14, 5.049e-14, 6.917e-14,
02725     8.88e-14, 1.115e-13, 1.373e-13, 1.619e-13, 1.878e-13, 2.111e-13,
02726     2.33e-13, 2.503e-13, 2.613e-13, 2.743e-13, 2.826e-13, 2.976e-13,
02727     3.162e-13, 3.36e-13, 3.491e-13, 3.541e-13, 3.595e-13, 3.608e-13,
02728     3.709e-13, 3.869e-13, 4.12e-13, 4.366e-13, 4.504e-13, 4.379e-13,
02729     3.955e-13, 3.385e-13, 2.741e-13, 2.089e-13, 1.427e-13, 9.294e-14,
02730     5.775e-14, 3.565e-14, 2.21e-14, 1.398e-14, 9.194e-15, 6.363e-15,
02731     4.644e-15, 3.55e-15, 2.808e-15, 2.274e-15, 1.871e-15, 1.557e-15,
02732     1.308e-15, 1.108e-15, 9.488e-16, 8.222e-16, 7.238e-16, 6.506e-16,
02733     6.008e-16, 5.742e-16, 5.724e-16, 5.991e-16, 6.625e-16, 7.775e-16,
02734     9.734e-16, 1.306e-15, 1.88e-15, 2.879e-15, 4.616e-15, 7.579e-15,
02735     1.248e-14, 2.03e-14, 3.244e-14, 5.171e-14, 7.394e-14, 9.676e-14,
02736     1.199e-13, 1.467e-13, 1.737e-13, 2.02e-13, 2.425e-13, 3.016e-13,
02737     3.7e-13, 4.617e-13, 5.949e-13, 7.473e-13, 9.378e-13, 1.191e-12,
02738     1.481e-12, 1.813e-12, 2.232e-12, 2.722e-12, 3.254e-12, 3.845e-12,
02739     4.458e-12, 5.048e-12, 5.511e-12, 5.898e-12, 6.204e-12, 6.293e-12,
02740     6.386e-12, 6.467e-12, 6.507e-12, 6.466e-12, 6.443e-12, 6.598e-12,
02741     6.873e-12, 7.3e-12, 7.816e-12, 8.368e-12, 8.643e-12, 8.466e-12,
02742     7.871e-12, 6.853e-12, 5.714e-12, 4.482e-12, 3.392e-12, 2.613e-12,
02743     2.008e-12, 1.562e-12, 1.228e-12, 9.888e-13, 7.646e-13, 5.769e-13,
02744     4.368e-13, 3.324e-13, 2.508e-13, 1.916e-13
02745   };
02746
02747   static double xfcrev[15] =
02748     { 1.003, 1.009, 1.015, 1.023, 1.029, 1.033, 1.037,
02749     1.039, 1.04, 1.046, 1.036, 1.027, 1.01, 1.002, 1.
02750   };
```

```
02751
02752   double a1, a2, a3, dw, ew, dx, xw, xx, vf2, vf6, cw260, cw296,
02753     sfac, fscal, cwfrn, ctmpth, ctwfrn, ctwslf;
02754
02755   int iw, ix;
02756
02757   /* Get H2O continuum absorption... */
02758   xw = nu / 10 + 1;
02759   if (xw >= 1 && xw < 2001) {
02760     iw = (int) xw;
02761     dw = xw - iw;
02762     ew = 1 - dw;
02763     cw296 = ew * h2o296[iw - 1] + dw * h2o296[iw];
02764     cw260 = ew * h2o260[iw - 1] + dw * h2o260[iw];
02765     cwfrn = ew * h2ofrn[iw - 1] + dw * h2ofrn[iw];
02766     if (nu <= 820 || nu >= 960) {
02767       sfac = 1;
02768     } else {
02769       xx = (nu - 820) / 10;
02770       ix = (int) xx;
02771       dx = xx - ix;
02772       sfac = (1 - dx) * xfcrev[ix] + dx * xfcrev[ix + 1];
02773     }
02774     ctwslf = sfac * cw296 * pow(cw260 / cw296, (296 - t) / (296 - 260));
02775     vf2 = POW2(nu - 370);
02776     vf6 = POW3(vf2);
02777     fscal = 36100 / (vf2 + vf6 * 1e-8 + 36100) * -.25 + 1;
02778     ctwfrn = cwfrn * fscal;
02779     a1 = nu * u * tanh(.7193876 / t * nu);
02780     a2 = 296 / t;
02781     a3 = p / P0 * (q * ctwslf + (1 - q) * ctwfrn) * 1e-20;
02782     ctmpth = a1 * a2 * a3;
02783   } else
02784     ctmpth = 0;
02785   return ctmpth;
02786 }
```

5.13.2.8 double ctmn2 (double *nu*, double *p*, double *t*)

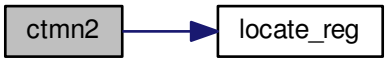
Compute nitrogen continuum (absorption coefficient).

Definition at line 2790 of file jurassic.c.

```
02793           {
02794
02795   static double ba[98] = { 0., 4.45e-8, 5.22e-8, 6.46e-8, 7.75e-8, 9.03e-8,
02796     1.06e-7, 1.21e-7, 1.37e-7, 1.57e-7, 1.75e-7, 2.01e-7, 2.3e-7,
02797     2.59e-7, 2.95e-7, 3.26e-7, 3.66e-7, 4.05e-7, 4.47e-7, 4.92e-7,
02798     5.34e-7, 5.84e-7, 6.24e-7, 6.67e-7, 7.14e-7, 7.26e-7, 7.54e-7,
02799     7.84e-7, 8.09e-7, 8.42e-7, 8.62e-7, 8.87e-7, 9.11e-7, 9.36e-7,
02800     9.76e-7, 1.03e-6, 1.11e-6, 1.23e-6, 1.39e-6, 1.61e-6, 1.76e-6,
02801     1.94e-6, 1.97e-6, 1.87e-6, 1.75e-6, 1.56e-6, 1.42e-6, 1.35e-6,
02802     1.32e-6, 1.29e-6, 1.29e-6, 1.29e-6, 1.3e-6, 1.32e-6, 1.33e-6,
02803     1.34e-6, 1.35e-6, 1.33e-6, 1.31e-6, 1.29e-6, 1.24e-6, 1.2e-6,
02804     1.16e-6, 1.1e-6, 1.04e-6, 9.96e-7, 9.38e-7, 8.63e-7, 7.98e-7,
02805     7.26e-7, 6.55e-7, 5.94e-7, 5.35e-7, 4.74e-7, 4.24e-7, 3.77e-7,
02806     3.33e-7, 2.96e-7, 2.63e-7, 2.34e-7, 2.08e-7, 1.85e-7, 1.67e-7,
02807     1.47e-7, 1.32e-7, 1.2e-7, 1.09e-7, 9.85e-8, 9.08e-8, 8.18e-8,
02808     7.56e-8, 6.85e-8, 6.14e-8, 5.83e-8, 5.77e-8, 5e-8, 4.32e-8, 0.
02809   };
02810
02811   static double betaa[98] = { 802., 802., 761., 722., 679., 646., 609., 562.,
02812     511., 472., 436., 406., 377., 355., 338., 319., 299., 278., 255.,
02813     233., 208., 184., 149., 107., 66., 25., -13., -49., -82., -104.,
02814     -119., -130., -139., -144., -146., -146., -147., -148., -150.,
02815     -153., -160., -169., -181., -189., -195., -200., -205., -209.,
02816     -211., -210., -210., -209., -205., -199., -190., -180., -168.,
02817     -157., -143., -126., -108., -89., -63., -32., 1., 35., 65., 95.,
02818     121., 141., 152., 161., 164., 164., 161., 155., 148., 143., 137.,
02819     133., 131., 133., 139., 150., 165., 187., 213., 248., 284., 321.,
02820     372., 449., 514., 569., 609., 642., 673., 673.
02821   };
02822
02823   static double nua[98] = { 2120., 2125., 2130., 2135., 2140., 2145., 2150.,
02824     2155., 2160., 2165., 2170., 2175., 2180., 2185., 2190., 2195.,
02825     2200., 2205., 2210., 2215., 2220., 2225., 2230., 2235., 2240.,
02826     2245., 2250., 2255., 2260., 2265., 2270., 2275., 2280., 2285.,
02827     2290., 2295., 2300., 2305., 2310., 2315., 2320., 2325., 2330.,
02828     2335., 2340., 2345., 2350., 2355., 2360., 2365., 2370., 2375.,
02829     2380., 2385., 2390., 2395., 2400., 2405., 2410., 2415., 2420.,
```

```
02830     2425., 2430., 2435., 2440., 2445., 2450., 2455., 2460., 2465.,
02831     2470., 2475., 2480., 2485., 2490., 2495., 2500., 2505., 2510.,
02832     2515., 2520., 2525., 2530., 2535., 2540., 2545., 2550., 2555.,
02833     2560., 2565., 2570., 2575., 2580., 2585., 2590., 2595., 2600., 2605.
02834   };
02835
02836   double b, beta, q_n2 = 0.79, t0 = 273, tr = 296;
02837
02838   int idx;
02839
02840   /* Check wavenumber range... */
02841   if (nu < nua[0] || nu > nua[97])
02842     return 0;
02843
02844   /* Interpolate B and beta... */
02845   idx = locate_reg(nua, 98, nu);
02846   b = LIN(nua[idx], ba[idx], nua[idx + 1], ba[idx + 1], nu);
02847   beta = LIN(nua[idx], betaa[idx], nua[idx + 1], betaa[idx + 1], nu);
02848
02849   /* Compute absorption coefficient... */
02850   return 0.1 * POW2(p / P0 * t0 / t) * exp(beta * (1 / tr - 1 / t))
02851     * q_n2 * b * (q_n2 + (1 - q_n2) * (1.294 - 0.4545 * t / tr));
02852 }
```

Here is the call graph for this function:



5.13.2.9 double ctmo2 (double *nu*, double *p*, double *t*)

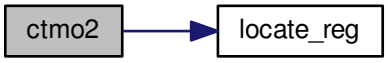
Compute oxygen continuum (absorption coefficient).

Definition at line 2856 of file jurassic.c.

```
02859             {
02860
02861   static double ba[90] = { 0., .061, .074, .084, .096, .12, .162, .208, .246,
02862     .285, .314, .38, .444, .5, .571, .673, .768, .853, .966, 1.097,
02863     1.214, 1.333, 1.466, 1.591, 1.693, 1.796, 1.922, 2.037, 2.154,
02864     2.264, 2.375, 2.508, 2.671, 2.847, 3.066, 3.417, 3.828, 4.204,
02865     4.453, 4.599, 4.528, 4.284, 3.955, 3.678, 3.477, 3.346, 3.29,
02866     3.251, 3.231, 3.226, 3.212, 3.192, 3.108, 3.033, 2.911, 2.798,
02867     2.646, 2.508, 2.322, 2.13, 1.928, 1.757, 1.588, 1.417, 1.253,
02868     1.109, .99, .888, .791, .678, .587, .524, .464, .403, .357, .32,
02869     .29, .267, .242, .215, .182, .16, .146, .128, .103, .087, .081,
02870     .071, .064, 0.
02871   };
02872
02873   static double betaa[90] = { 467., 467., 400., 315., 379., 368., 475., 521.,
02874     531., 512., 442., 444., 430., 381., 335., 324., 296., 248., 215.,
02875     193., 158., 127., 101., 71., 31., -6., -26., -47., -63., -79.,
02876     -88., -88., -87., -90., -98., -99., -109., -134., -160., -167.,
02877     -164., -158., -153., -151., -156., -166., -168., -173., -170.,
02878     -161., -145., -126., -108., -84., -59., -29., 4., 41., 73., 97.,
02879     123., 159., 198., 220., 242., 256., 281., 311., 334., 319., 313.,
02880     321., 323., 310., 315., 320., 335., 361., 378., 373., 338., 319.,
02881     346., 322., 291., 290., 350., 371., 504., 504.
02882   };
02883
02884   static double nua[90] = { 1360., 1365., 1370., 1375., 1380., 1385., 1390.,
02885     1395., 1400., 1405., 1410., 1415., 1420., 1425., 1430., 1435.,
02886     1440., 1445., 1450., 1455., 1460., 1465., 1470., 1475., 1480.,
02887     1485., 1490., 1495., 1500., 1505., 1510., 1515., 1520., 1525.,
02888     1530., 1535., 1540., 1545., 1550., 1555., 1560., 1565., 1570.,
```

```
02889     1575., 1580., 1585., 1590., 1595., 1600., 1605., 1610., 1615.,
02890     1620., 1625., 1630., 1635., 1640., 1645., 1650., 1655., 1660.,
02891     1665., 1670., 1675., 1680., 1685., 1690., 1695., 1700., 1705.,
02892     1710., 1715., 1720., 1725., 1730., 1735., 1740., 1745., 1750.,
02893     1755., 1760., 1765., 1770., 1775., 1780., 1785., 1790., 1795.,
02894     1800., 1805.
02895   };
02896
02897   double b, beta, q_o2 = 0.21, t0 = 273, tr = 296;
02898
02899   int idx;
02900
02901   /* Check wavenumber range... */
02902   if (nu < nua[0] || nu > nua[89])
02903     return 0;
02904
02905   /* Interpolate B and beta... */
02906   idx = locate_reg(nua, 90, nu);
02907   b = LIN(nua[idx], ba[idx], nua[idx + 1], ba[idx + 1], nu);
02908   beta = LIN(nua[idx], betaa[idx], nua[idx + 1], betaa[idx + 1], nu);
02909
02910   /* Compute absorption coefficient... */
02911   return 0.1 * POW2(p / P0 * t0 / t) * exp(beta * (1 / tr - 1 / t)) * q_o2 *
02912     b;
02913 }
```

Here is the call graph for this function:



5.13.2.10 void copy_atm (ctl_t * *ctl*, atm_t * *atm_dest*, atm_t * *atm_src*, int *init*)

Copy and initialize atmospheric data.

Definition at line 2917 of file jurassic.c.

```
02921             {
02922
02923   int ig, ip, iw;
02924
02925   size_t s;
02926
02927   /* Data size... */
02928   s = (size_t) atm_src->np * sizeof(double);
02929
02930   /* Copy data... */
02931   atm_dest->np = atm_src->np;
02932   memcpy(atm_dest->time, atm_src->time, s);
02933   memcpy(atm_dest->z, atm_src->z, s);
02934   memcpy(atm_dest->lon, atm_src->lon, s);
02935   memcpy(atm_dest->lat, atm_src->lat, s);
02936   memcpy(atm_dest->p, atm_src->p, s);
02937   memcpy(atm_dest->t, atm_src->t, s);
02938   for (ig = 0; ig < ctl->ng; ig++)
02939     memcpy(atm_dest->q[ig], atm_src->q[ig], s);
02940   for (iw = 0; iw < ctl->nw; iw++)
02941     memcpy(atm_dest->k[iw], atm_src->k[iw], s);
02942
02943   /* Initialize... */
02944   if (init)
02945     for (ip = 0; ip < atm_dest->np; ip++) {
02946       atm_dest->p[ip] = 0;
02947       atm_dest->t[ip] = 0;
02948       for (ig = 0; ig < ctl->ng; ig++)
02949         atm_dest->q[ig][ip] = 0;
02950       for (iw = 0; iw < ctl->nw; iw++)
02951         atm_dest->k[iw][ip] = 0;
02952     }
02953 }
```

5.13.2.11 void copy_obs (ctl_t * *ctl*, obs_t * *obs_dest*, obs_t * *obs_src*, int *init*)

Copy and initialize observation data.

Definition at line 2957 of file jurassic.c.

```
02961             {
02962
02963   int id, ir;
02964
02965   size_t s;
02966
02967   /* Data size... */
02968   s = (size_t) obs_src->nr * sizeof(double);
02969
02970   /* Copy data... */
02971   obs_dest->nr = obs_src->nr;
02972   memcpy(obs_dest->time, obs_src->time, s);
02973   memcpy(obs_dest->obsz, obs_src->obsz, s);
02974   memcpy(obs_dest->obslon, obs_src->obslon, s);
02975   memcpy(obs_dest->obslat, obs_src->obslat, s);
02976   memcpy(obs_dest->vpz, obs_src->vpz, s);
02977   memcpy(obs_dest->vplon, obs_src->vplon, s);
02978   memcpy(obs_dest->vplat, obs_src->vplat, s);
02979   memcpy(obs_dest->tpz, obs_src->tpz, s);
02980   memcpy(obs_dest->tplon, obs_src->tplon, s);
02981   memcpy(obs_dest->tplat, obs_src->tplat, s);
02982   for (id = 0; id < ctl->nd; id++)
02983     memcpy(obs_dest->rad[id], obs_src->rad[id], s);
02984   for (id = 0; id < ctl->nd; id++)
02985     memcpy(obs_dest->tau[id], obs_src->tau[id], s);
02986
02987   /* Initialize... */
02988   if (init)
02989     for (id = 0; id < ctl->nd; id++)
02990       for (ir = 0; ir < obs_dest->nr; ir++)
02991         if (gsl_finite(obs_dest->rad[id][ir])) {
02992           obs_dest->rad[id][ir] = 0;
02993           obs_dest->tau[id][ir] = 0;
02994         }
02995 }
```

5.13.2.12 int find_emitter (ctl_t * *ctl*, const char * *emitter*)

Find index of an emitter.

Definition at line 2999 of file jurassic.c.

```
03001                         {
03002
03003   int ig;
03004
03005   for (ig = 0; ig < ctl->ng; ig++)
03006     if (strcasecmp(ctl->emitter[ig], emitter) == 0)
03007       return ig;
03008
03009   return -1;
03010 }
```

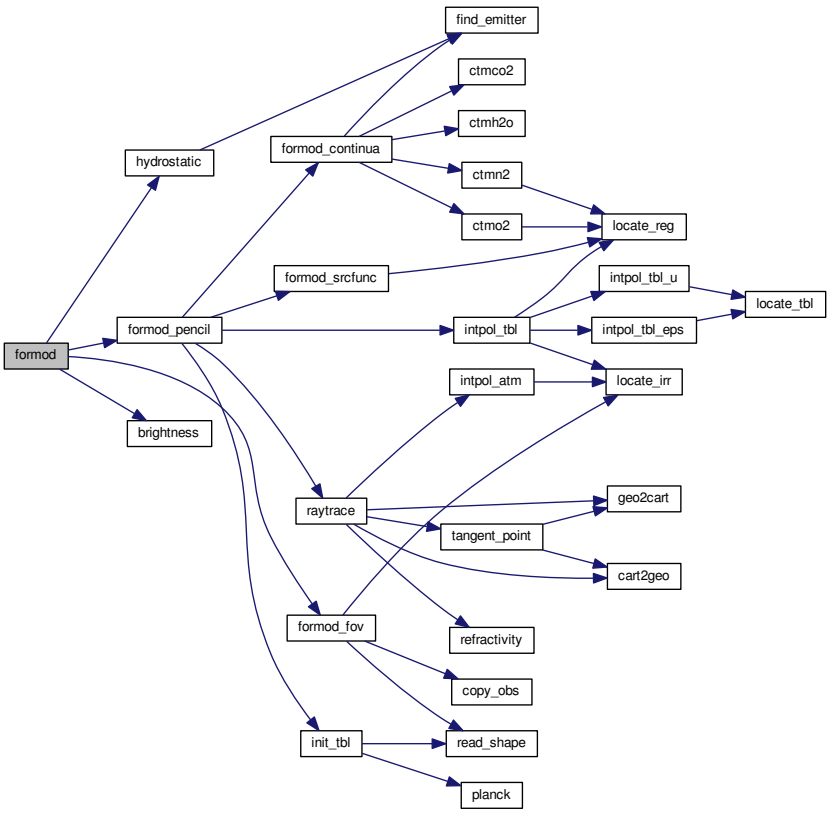
5.13.2.13 void formod (ctl_t * *ctl*, atm_t * *atm*, obs_t * *obs*)

Determine ray paths and compute radiative transfer.

Definition at line 3014 of file jurassic.c.

```
03017                {
03018
03019   int id, ir, *mask;
03020
03021   /* Allocate... */
03022   ALLOC(mask, int,
03023         ND * NR);
03024
03025   /* Save observation mask... */
03026   for (id = 0; id < ctl->nd; id++)
03027     for (ir = 0; ir < obs->nr; ir++)
03028       mask[id * NR + ir] = !gsl_finite(obs->rad[id][ir]);
03029
03030   /* Hydrostatic equilibrium... */
03031   hydrostatic(ctl, atm);
03032
03033   /* Calculate pencil beams... */
03034   for (ir = 0; ir < obs->nr; ir++)
03035     formod_pencil(ctl, atm, obs, ir);
03036
03037   /* Apply field-of-view convolution... */
03038   formod_fov(ctl, obs);
03039
03040   /* Convert radiance to brightness temperature... */
03041   if (ctl->write_bbt)
03042     for (id = 0; id < ctl->nd; id++)
03043       for (ir = 0; ir < obs->nr; ir++)
03044         obs->rad[id][ir] = brightness(obs->rad[id][ir], ctl->nu[id]);
03045
03046   /* Apply observation mask... */
03047   for (id = 0; id < ctl->nd; id++)
03048     for (ir = 0; ir < obs->nr; ir++)
03049       if (mask[id * NR + ir])
03050         obs->rad[id][ir] = GSL_NAN;
03051
03052   /* Free... */
03053   free(mask);
03054 }
```

Here is the call graph for this function:



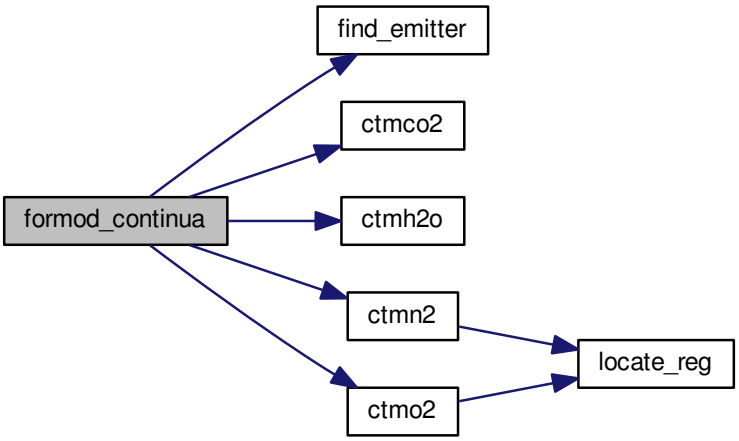
5.13.2.14 void formod_continua (ctl_t * *ctl*, los_t * *los*, int *ip*, double * *beta*)

Compute absorption coefficient of continua.

Definition at line 3058 of file jurassic.c.

```
03062                {
03063
03064   static int ig_co2 = -999, ig_h2o = -999;
03065
03066   int id;
03067
03068   /* Extinction... */
03069   for (id = 0; id < ctl->nd; id++)
03070     beta[id] = los->k[ctl->window[id]][ip];
03071
03072   /* CO2 continuum... */
03073   if (ctl->ctm_co2) {
03074     if (ig_co2 == -999)
03075       ig_co2 = find_emitter(ctl, "CO2");
03076     if (ig_co2 >= 0)
03077       for (id = 0; id < ctl->nd; id++)
03078         beta[id] += ctmco2(ctl->nu[id], los->p[ip], los->t[ip],
03079                            los->u[ig_co2][ip]) / los->ds[ip];
03080   }
03081
03082   /* H2O continuum... */
03083   if (ctl->ctm_h2o) {
03084     if (ig_h2o == -999)
03085       ig_h2o = find_emitter(ctl, "H2O");
03086     if (ig_h2o >= 0)
03087       for (id = 0; id < ctl->nd; id++)
03088         beta[id] += ctmh2o(ctl->nu[id], los->p[ip], los->t[ip],
03089                            los->q[ig_h2o][ip],
03090                            los->u[ig_h2o][ip]) / los->ds[ip];
03091   }
03092
03093   /* N2 continuum... */
03094   if (ctl->ctm_n2)
03095     for (id = 0; id < ctl->nd; id++)
03096       beta[id] += ctmn2(ctl->nu[id], los->p[ip], los->t[ip]);
03097
03098   /* O2 continuum... */
03099   if (ctl->ctm_o2)
03100     for (id = 0; id < ctl->nd; id++)
03101       beta[id] += ctmo2(ctl->nu[id], los->p[ip], los->t[ip]);
03102 }
```

Here is the call graph for this function:



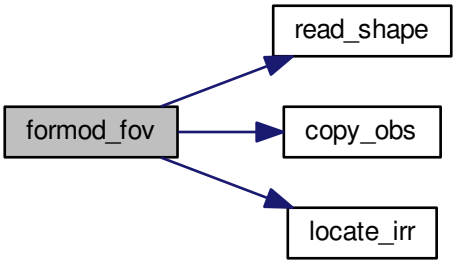
5.13.2.15 void formod_fov (ctl_t * *ctl*, obs_t * *obs*)

Apply field of view convolution.

Definition at line 3106 of file jurassic.c.

```
03108               {
03109
03110   static double dz[NSHAPE], w[NSHAPE];
03111
03112   static int init = 0, n;
03113
03114   obs_t *obs2;
03115
03116   double rad[ND][NR], tau[ND][NR], wsum, z[NR], zfov;
03117
03118   int i, id, idx, ir, ir2, nz;
03119
03120   /* Do not take into account FOV... */
03121   if (ctl->fov[0] == '-')
03122     return;
03123
03124   /* Initialize FOV data... */
03125   if (!init) {
03126     init = 1;
03127     read_shape(ctl->fov, dz, w, &n);
03128   }
03129
03130   /* Allocate... */
03131   ALLOC(obs2, obs_t, 1);
03132
03133   /* Copy observation data... */
03134   copy_obs(ctl, obs2, obs, 0);
03135
03136   /* Loop over ray paths... */
03137   for (ir = 0; ir < obs->nr; ir++) {
03138
03139     /* Get radiance and transmittance profiles... */
03140     nz = 0;
03141     for (ir2 = GSL_MAX(ir - NFOV, 0); ir2 < GSL_MIN(ir + 1 + NFOV, obs->nr);
03142          ir2++)
03143       if (obs->time[ir2] == obs->time[ir]) {
03144         z[nz] = obs2->vpz[ir2];
03145         for (id = 0; id < ctl->nd; id++) {
03146           rad[id][nz] = obs2->rad[id][ir2];
03147           tau[id][nz] = obs2->tau[id][ir2];
03148         }
03149         nz++;
03150       }
03151     if (nz < 2)
03152       ERRMSG("Cannot apply FOV convolution!");
03153
03154     /* Convolute profiles with FOV... */
03155     wsum = 0;
03156     for (id = 0; id < ctl->nd; id++) {
03157       obs->rad[id][ir] = 0;
03158       obs->tau[id][ir] = 0;
03159     }
03160     for (i = 0; i < n; i++) {
03161       zfov = obs->vpz[ir] + dz[i];
03162       idx = locate_irr(z, nz, zfov);
03163       for (id = 0; id < ctl->nd; id++) {
03164         obs->rad[id][ir] += w[i]
03165           * LIN(z[idx], rad[id][idx], z[idx + 1], rad[id][idx + 1], zfov);
03166         obs->tau[id][ir] += w[i]
03167           * LIN(z[idx], tau[id][idx], z[idx + 1], tau[id][idx + 1], zfov);
03168       }
03169       wsum += w[i];
03170     }
03171     for (id = 0; id < ctl->nd; id++) {
03172       obs->rad[id][ir] /= wsum;
03173       obs->tau[id][ir] /= wsum;
03174     }
03175   }
03176
03177   /* Free... */
03178   free(obs2);
03179 }
```

Here is the call graph for this function:



5.13.2.16 void formod_pencil (ctl_t * *ctl*, atm_t * *atm*, obs_t * *obs*, int *ir*)

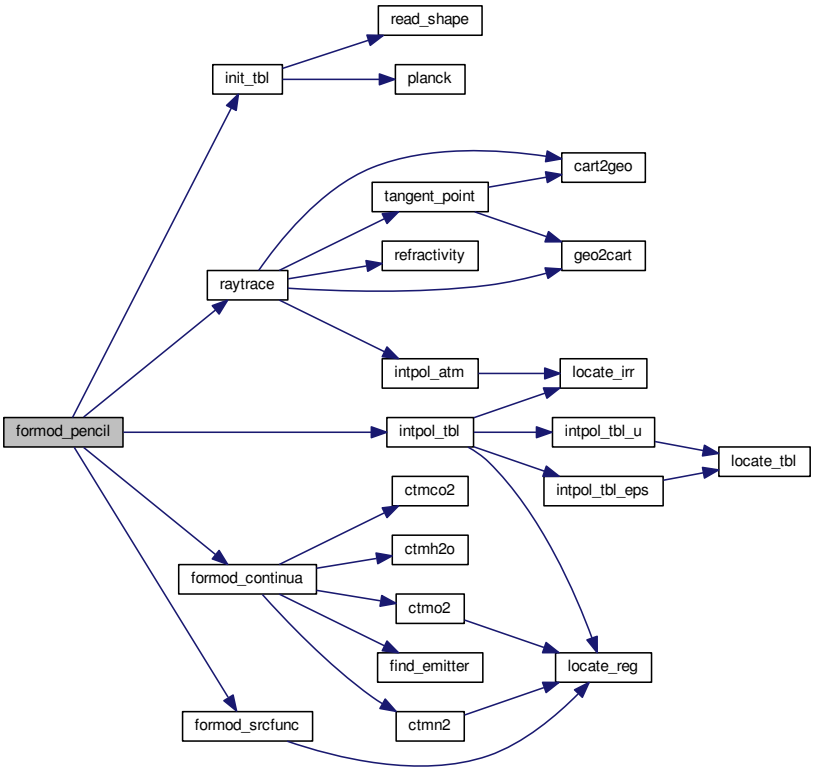
Compute radiative transfer for a pencil beam.

Definition at line 3183 of file jurassic.c.

```
03187           {
03188
03189     static tbl_t *tbl;
03190
03191     static int init = 0;
03192
03193     los_t *los;
03194
03195     double beta_ctm[ND], eps, src_planck[ND], tau_path[NG][ND], tau_gas[ND];
03196
03197     int id, ip;
03198
03199     /* Initialize look-up tables... */
03200     if (!init) {
03201       init = 1;
03202       ALLOC(tbl, tbl_t, 1);
03203       init_tbl(ctl, tbl);
03204     }
03205
03206     /* Allocate... */
03207     ALLOC(los, los_t, 1);
03208
03209     /* Initialize... */
03210     for (id = 0; id < ctl->nd; id++) {
03211       obs->rad[id][ir] = 0;
03212       obs->tau[id][ir] = 1;
03213     }
03214
03215     /* Raytracing... */
03216     raytrace(ctl, atm, obs, los, ir);
03217
03218     /* Loop over LOS points... */
03219     for (ip = 0; ip < los->np; ip++) {
03220
03221       /* Get trace gas transmittance... */
03222       intpol_tbl(ctl, tbl, los, ip, tau_path, tau_gas);
03223
03224       /* Get continuum absorption... */
03225       formod_continua(ctl, los, ip, beta_ctm);
03226
03227       /* Compute Planck function... */
03228       formod_srcfunc(ctl, tbl, los->t[ip], src_planck);
03229
03230       /* Loop over channels... */
03231       for (id = 0; id < ctl->nd; id++)
03232         if (tau_gas[id] > 0) {
03233
```

```
03234         /* Get segment emissivity... */
03235         eps = 1 - tau_gas[id] * exp(-beta_ctm[id] * los->ds[ip]);
03236
03237         /* Compute radiance... */
03238         obs->rad[id][ir] += src_planck[id] * eps * obs->tau[id][ir];
03239
03240         /* Compute path transmittance... */
03241         obs->tau[id][ir] *= (1 - eps);
03242       }
03243   }
03244
03245   /* Add surface... */
03246   if (los->tsurf > 0) {
03247     formod_srcfunc(ctl, tbl, los->tsurf, src_planck);
03248     for (id = 0; id < ctl->nd; id++)
03249       obs->rad[id][ir] += src_planck[id] * obs->tau[id][ir];
03250   }
03251
03252   /* Free... */
03253   free(los);
03254 }
```

Here is the call graph for this function:



5.13.2.17 void formod_srcfunc (ctl_t * *ctl*, tbl_t * *tbl*, double *t*, double * *src*)

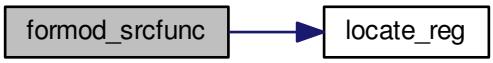
Compute Planck source function.

Definition at line 3258 of file jurassic.c.

```
03262                 {
03263
03264   int id, it;
```

```
03265
03266   /* Determine index in temperature array... */
03267   it = locate_reg(tbl->st, TBLNS, t);
03268
03269   /* Interpolate Planck function value... */
03270   for (id = 0; id < ctl->nd; id++)
03271     src[id] = LIN(tbl->st[it], tbl->sr[id][it],
03272                   tbl->st[it + 1], tbl->sr[id][it + 1], t);
03273 }
```

Here is the call graph for this function:



5.13.2.18 void geo2cart (double *z*, double *lon*, double *lat*, double * *x*)

Convert geolocation to Cartesian coordinates.

Definition at line 3277 of file jurassic.c.

```
03281             {
03282
03283   double radius;
03284
03285   radius = z + RE;
03286   x[0] = radius * cos(lat / 180 * M_PI) * cos(lon / 180 * M_PI);
03287   x[1] = radius * cos(lat / 180 * M_PI) * sin(lon / 180 * M_PI);
03288   x[2] = radius * sin(lat / 180 * M_PI);
03289 }
```

5.13.2.19 void hydrostatic (ctl_t * *ctl*, atm_t * *atm*)

Set hydrostatic equilibrium.

Definition at line 3293 of file jurassic.c.

```
03295               {
03296
03297   static int ig_h2o = -999;
03298
03299   double dzmin = 1e99, e = 0, mean, mmair = 28.96456e-3, mmh2o = 18.0153e-3;
03300
03301   int i, ip, ipref = 0, ipts = 20;
03302
03303   /* Check reference height... */
03304   if (ctl->hydz < 0)
03305     return;
03306
03307   /* Determine emitter index of H2O... */
03308   if (ig_h2o == -999)
03309     ig_h2o = find_emitter(ctl, "H2O");
03310
03311   /* Find air parcel next to reference height... */
03312   for (ip = 0; ip < atm->np; ip++)
03313     if (fabs(atm->z[ip] - ctl->hydz) < dzmin) {
03314       dzmin = fabs(atm->z[ip] - ctl->hydz);
03315       ipref = ip;
03316     }
```

```
03317
03318   /* Upper part of profile... */
03319   for (ip = ipref + 1; ip < atm->np; ip++) {
03320     mean = 0;
03321     for (i = 0; i < ipts; i++) {
03322       if (ig_h2o >= 0)
03323         e = LIN(0.0, atm->q[ig_h2o][ip - 1],
03324                 ipts - 1.0, atm->q[ig_h2o][ip], (double) i);
03325       mean += (e * mmh2o + (1 - e) * mmair)
03326         * G0 / RI
03327         / LIN(0.0, atm->t[ip - 1], ipts - 1.0, atm->t[ip], (double) i) / ipts;
03328     }
03329
03330     /* Compute p(z,T)... */
03331     atm->p[ip] =
03332       exp(log(atm->p[ip - 1]) - mean * 1000 * (atm->z[ip] - atm->z[ip - 1]));
03333   }
03334
03335   /* Lower part of profile... */
03336   for (ip = ipref - 1; ip >= 0; ip--) {
03337     mean = 0;
03338     for (i = 0; i < ipts; i++) {
03339       if (ig_h2o >= 0)
03340         e = LIN(0.0, atm->q[ig_h2o][ip + 1],
03341                 ipts - 1.0, atm->q[ig_h2o][ip], (double) i);
03342       mean += (e * mmh2o + (1 - e) * mmair)
03343         * G0 / RI
03344         / LIN(0.0, atm->t[ip + 1], ipts - 1.0, atm->t[ip], (double) i) / ipts;
03345     }
03346
03347     /* Compute p(z,T)... */
03348     atm->p[ip] =
03349       exp(log(atm->p[ip + 1]) - mean * 1000 * (atm->z[ip] - atm->z[ip + 1]));
03350   }
03351 }
```

Here is the call graph for this function:

5.13.2.20 void idx2name (ctl_t * *ctl*, int *idx*, char * *quantity*)

Determine name of state vector quantity for given index.

Definition at line 3355 of file jurassic.c.

```
03358                   {
03359
03360   int ig, iw;
03361
03362   if (idx == IDXP)
03363     sprintf(quantity, "PRESSURE");
03364
03365   if (idx == IDXT)
03366     sprintf(quantity, "TEMPERATURE");
03367
03368   for (ig = 0; ig < ctl->ng; ig++)
03369     if (idx == IDXQ(ig))
03370       sprintf(quantity, "%s", ctl->emitter[ig]);
03371
03372   for (iw = 0; iw < ctl->nw; iw++)
03373     if (idx == IDXK(iw))
03374       sprintf(quantity, "EXTINCT_WINDOW%d", iw);
03375 }
```

5.13.2.21 void init_tbl (ctl_t * *ctl*, tbl_t * *tbl*)

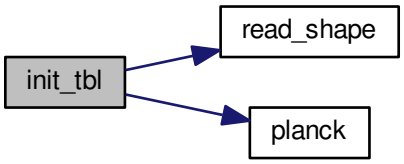
Initialize look-up tables.

Definition at line 3379 of file jurassic.c.

```
03381               {
03382
03383   FILE *in;
03384
03385   char filename[2 * LEN], line[LEN];
03386
03387   double eps, eps_old, press, press_old, temp, temp_old, u, u_old,
03388     f[NSHAPE], fsum, nu[NSHAPE];
03389
03390   int i, id, ig, ip, it, n;
03391
03392   /* Loop over trace gases and channels... */
03393   for (ig = 0; ig < ctl->ng; ig++)
03394 #pragma omp parallel for default(none) shared(ctl,tbl,ig) private(in,filename,line,eps,eps_old,press,
      press_old,temp,temp_old,u,u_old,id,ip,it)
03395     for (id = 0; id < ctl->nd; id++) {
03396
03397       /* Initialize... */
03398       tbl->np[ig][id] = -1;
03399       eps_old = -999;
03400       press_old = -999;
03401       temp_old = -999;
03402       u_old = -999;
03403
03404       /* Try to open file... */
03405       sprintf(filename, "%s_%.4f_%s.tab",
03406               ctl->tblbase, ctl->nu[id], ctl->emitter[ig]);
03407       if (!(in = fopen(filename, "r"))) {
03408         printf("Missing emissivity table: %s\n", filename);
03409         continue;
03410       }
03411       printf("Read emissivity table: %s\n", filename);
03412
03413       /* Read data... */
03414       while (fgets(line, LEN, in)) {
03415
03416         /* Parse line... */
03417         if (sscanf(line, "%lg %lg %lg %lg", &press, &temp, &u, &eps) != 4)
03418           continue;
03419
03420         /* Determine pressure index... */
03421         if (press != press_old) {
03422           press_old = press;
03423           if ((++tbl->np[ig][id]) >= TBLNP)
03424             ERRMSG("Too many pressure levels!");
03425           tbl->nt[ig][id][tbl->np[ig][id]] = -1;
03426         }
03427
03428         /* Determine temperature index... */
03429         if (temp != temp_old) {
03430           temp_old = temp;
03431           if ((++tbl->nt[ig][id][tbl->np[ig][id]]) >= TBLNT)
03432             ERRMSG("Too many temperatures!");
03433           tbl->nu[ig][id][tbl->np[ig][id]]
03434             [tbl->nt[ig][id][tbl->np[ig][id]]] = -1;
03435         }
03436
03437         /* Determine column density index... */
03438         if ((eps > eps_old && u > u_old) || tbl->nu[ig][id][tbl->np[ig][id]]
03439             [tbl->nt[ig][id][tbl->np[ig][id]]] < 0) {
03440           eps_old = eps;
03441           u_old = u;
03442           if ((++tbl->nu[ig][id][tbl->np[ig][id]]
03443                [tbl->nt[ig][id][tbl->np[ig][id]]]) >= TBLNU) {
03444             tbl->nu[ig][id][tbl->np[ig][id]]
03445               [tbl->nt[ig][id][tbl->np[ig][id]]]--;
03446             continue;
03447           }
03448         }
03449
03450         /* Store data... */
03451         tbl->p[ig][id][tbl->np[ig][id]] = press;
03452         tbl->t[ig][id][tbl->np[ig][id]][tbl->nt[ig][id][tbl->np[ig][id]]]
03453           = temp;
03454         tbl->u[ig][id][tbl->np[ig][id]][tbl->nt[ig][id][tbl->np[ig][id]]]
03455           [tbl->nu[ig][id][tbl->np[ig][id]]
03456            [tbl->nt[ig][id][tbl->np[ig][id]]]] = (float) u;
```

```
03457         tbl->eps[ig][id][tbl->np[ig][id]][tbl->nt[ig][id][tbl->np[ig][id]]]
03458           [tbl->nu[ig][id][tbl->np[ig][id]]
03459            [tbl->nt[ig][id][tbl->np[ig][id]]]] = (float) eps;
03460       }
03461
03462       /* Increment counters... */
03463       tbl->np[ig][id]++;
03464       for (ip = 0; ip < tbl->np[ig][id]; ip++) {
03465         tbl->nt[ig][id][ip]++;
03466         for (it = 0; it < tbl->nt[ig][id][ip]; it++)
03467           tbl->nu[ig][id][ip][it]++;
03468       }
03469
03470       /* Close file... */
03471       fclose(in);
03472     }
03473
03474   /* Write info... */
03475   printf("Initialize source function table...\n");
03476
03477   /* Loop over channels... */
03478 #pragma omp parallel for default(none) shared(ctl,tbl,ig) private(filename,it,i,n,f,fsum,nu)
03479   for (id = 0; id < ctl->nd; id++) {
03480
03481     /* Read filter function... */
03482     sprintf(filename, "%s_%.4f.filt", ctl->tblbase, ctl->nu[id]);
03483     read_shape(filename, nu, f, &n);
03484
03485     /* Compute source function table... */
03486     for (it = 0; it < TBLNS; it++) {
03487
03488       /* Set temperature... */
03489       tbl->st[it] = LIN(0.0, TMIN, TBLNS - 1.0, TMAX, (double) it);
03490
03491       /* Integrate Planck function... */
03492       fsum = 0;
03493       tbl->sr[id][it] = 0;
03494       for (i = 0; i < n; i++) {
03495         fsum += f[i];
03496         tbl->sr[id][it] += f[i] * planck(tbl->st[it], nu[i]);
03497       }
03498       tbl->sr[id][it] /= fsum;
03499     }
03500   }
03501 }
```

Here is the call graph for this function:



5.13.2.22 void intpol_atm (ctl_t * *ctl*, atm_t * *atm*, double *z*, double * *p*, double * *t*, double * *q*, double * *k*)

Interpolate atmospheric data.

Definition at line 3505 of file jurassic.c.

```
03512              {
03513
03514   int ig, ip, iw;
03515
```

```
03516   /* Get array index... */
03517   ip = locate_irr(atm->z, atm->np, z);
03518
03519   /* Interpolate... */
03520   *p = EXP(atm->z[ip], atm->p[ip], atm->z[ip + 1], atm->p[ip + 1], z);
03521   *t = LIN(atm->z[ip], atm->t[ip], atm->z[ip + 1], atm->t[ip + 1], z);
03522   for (ig = 0; ig < ctl->ng; ig++)
03523     q[ig] =
03524       LIN(atm->z[ip], atm->q[ig][ip], atm->z[ip + 1], atm->q[ig][ip + 1], z);
03525   for (iw = 0; iw < ctl->nw; iw++)
03526     k[iw] =
03527       LIN(atm->z[ip], atm->k[iw][ip], atm->z[ip + 1], atm->k[iw][ip + 1], z);
03528 }
```

Here is the call graph for this function:

5.13.2.23 void intpol_tbl (ctl_t * *ctl*, tbl_t * *tbl*, los_t * *los*, int *ip*, double *tau_path[NG][ND]*, double *tau_seg[ND]*)

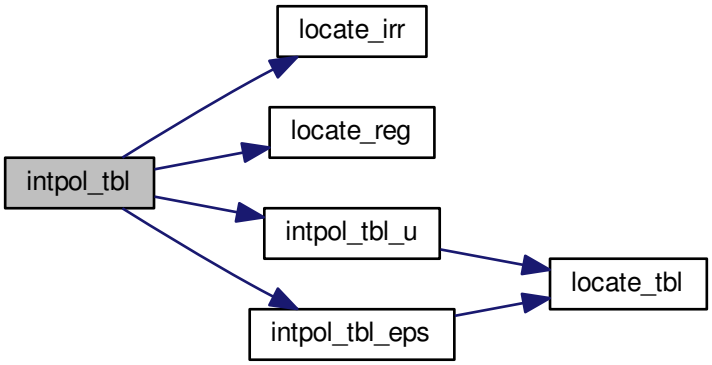
Get transmittance from look-up tables.

Definition at line 3532 of file jurassic.c.

```
03538                       {
03539
03540   double eps, eps00, eps01, eps10, eps11, u;
03541
03542   int id, ig, ipr, it0, it1;
03543
03544   /* Initialize... */
03545   if (ip <= 0)
03546     for (ig = 0; ig < ctl->ng; ig++)
03547       for (id = 0; id < ctl->nd; id++)
03548         tau_path[ig][id] = 1;
03549
03550   /* Loop over channels... */
03551   for (id = 0; id < ctl->nd; id++) {
03552
03553     /* Initialize... */
03554     tau_seg[id] = 1;
03555
03556     /* Loop over emitters.... */
03557     for (ig = 0; ig < ctl->ng; ig++) {
03558
03559       /* Check size of table (pressure)... */
03560       if (tbl->np[ig][id] < 2)
03561         eps = 0;
03562
03563       /* Check transmittance... */
03564       else if (tau_path[ig][id] < 1e-9)
03565         eps = 1;
03566
03567       /* Interpolate... */
03568       else {
03569
03570         /* Determine pressure and temperature indices... */
03571         ipr = locate_irr(tbl->p[ig][id], tbl->np[ig][id], los->p[ip]);
03572         it0 =
03573           locate_irr(tbl->t[ig][id][ipr], tbl->nt[ig][id][ipr], los->
    t[ip]);
03574         it1 =
03575           locate_reg(tbl->t[ig][id][ipr + 1], tbl->nt[ig][id][ipr + 1],
03576                      los->t[ip]);
```

```
03577
03578         /* Check size of table (temperature and column density)... */
03579         if (tbl->nt[ig][id][ipr] < 2 || tbl->nt[ig][id][ipr + 1] < 2
03580             || tbl->nu[ig][id][ipr][it0] < 2
03581             || tbl->nu[ig][id][ipr][it0 + 1] < 2
03582             || tbl->nu[ig][id][ipr + 1][it1] < 2
03583             || tbl->nu[ig][id][ipr + 1][it1 + 1] < 2)
03584           eps = 0;
03585
03586         else {
03587
03588           /* Get emissivities of extended path... */
03589           u = intpol_tbl_u(tbl, ig, id, ipr, it0, 1 - tau_path[ig][id]);
03590           eps00 = intpol_tbl_eps(tbl, ig, id, ipr, it0, u + los->u[ig][ip]);
03591
03592           u = intpol_tbl_u(tbl, ig, id, ipr, it0 + 1, 1 - tau_path[ig][id]);
03593           eps01 =
03594             intpol_tbl_eps(tbl, ig, id, ipr, it0 + 1, u + los->u[ig][ip]);
03595
03596           u = intpol_tbl_u(tbl, ig, id, ipr + 1, it1, 1 - tau_path[ig][id]);
03597           eps10 =
03598             intpol_tbl_eps(tbl, ig, id, ipr + 1, it1, u + los->u[ig][ip]);
03599
03600           u =
03601             intpol_tbl_u(tbl, ig, id, ipr + 1, it1 + 1, 1 - tau_path[ig][id]);
03602           eps11 =
03603             intpol_tbl_eps(tbl, ig, id, ipr + 1, it1 + 1, u + los->
    u[ig][ip]);
03604
03605           /* Interpolate with respect to temperature... */
03606           eps00 = LIN(tbl->t[ig][id][ipr][it0], eps00,
03607                       tbl->t[ig][id][ipr][it0 + 1], eps01, los->t[ip]);
03608           eps11 = LIN(tbl->t[ig][id][ipr + 1][it1], eps10,
03609                       tbl->t[ig][id][ipr + 1][it1 + 1], eps11, los->t[ip]);
03610
03611           /* Interpolate with respect to pressure... */
03612           eps00 = LIN(tbl->p[ig][id][ipr], eps00,
03613                       tbl->p[ig][id][ipr + 1], eps11, los->p[ip]);
03614
03615           /* Check emssivity range... */
03616           eps00 = GSL_MAX(GSL_MIN(eps00, 1), 0);
03617
03618           /* Determine segment emissivity... */
03619           eps = 1 - (1 - eps00) / tau_path[ig][id];
03620         }
03621       }
03622
03623       /* Get transmittance of extended path... */
03624       tau_path[ig][id] *= (1 - eps);
03625
03626       /* Get segment transmittance... */
03627       tau_seg[id] *= (1 - eps);
03628     }
03629   }
03630 }
```

Here is the call graph for this function:



5.13.2.24 double intpol_tbl_eps (tbl_t * *tbl*, int *ig*, int *id*, int *ip*, int *it*, double *u*)

Interpolate emissivity from look-up tables.

Definition at line 3634 of file jurassic.c.

```
03640             {
03641
03642   int idx;
03643
03644   /* Lower boundary... */
03645   if (u < tbl->u[ig][id][ip][it][0])
03646     return LIN(0, 0, tbl->u[ig][id][ip][it][0], tbl->eps[ig][id][ip][it][0],
03647                u);
03648
03649   /* Upper boundary... */
03650   else if (u > tbl->u[ig][id][ip][it][tbl->nu[ig][id][ip][it] - 1])
03651     return LIN(tbl->u[ig][id][ip][it][tbl->nu[ig][id][ip][it] - 1],
03652                tbl->eps[ig][id][ip][it][tbl->nu[ig][id][ip][it] - 1],
03653                1e30, 1, u);
03654
03655   /* Interpolation... */
03656   else {
03657
03658     /* Get index... */
03659     idx = locate_tbl(tbl->u[ig][id][ip][it], tbl->nu[ig][id][ip][it], u);
03660
03661     /* Interpolate... */
03662     return
03663       LIN(tbl->u[ig][id][ip][it][idx], tbl->eps[ig][id][ip][it][idx],
03664           tbl->u[ig][id][ip][it][idx + 1], tbl->eps[ig][id][ip][it][idx + 1],
03665           u);
03666   }
03667 }
```

Here is the call graph for this function:

5.13.2.25 double intpol_tbl_u (tbl_t * *tbl*, int *ig*, int *id*, int *ip*, int *it*, double *eps*)

Interpolate column density from look-up tables.

Definition at line 3671 of file jurassic.c.

```
03677             {
03678
03679   int idx;
03680
03681   /* Lower boundary... */
03682   if (eps < tbl->eps[ig][id][ip][it][0])
03683     return LIN(0, 0, tbl->eps[ig][id][ip][it][0], tbl->u[ig][id][ip][it][0],
03684                eps);
03685
03686   /* Upper boundary... */
03687   else if (eps > tbl->eps[ig][id][ip][it][tbl->nu[ig][id][ip][it] - 1])
03688     return LIN(tbl->eps[ig][id][ip][it][tbl->nu[ig][id][ip][it] - 1],
03689                tbl->u[ig][id][ip][it][tbl->nu[ig][id][ip][it] - 1],
03690                1, 1e30, eps);
03691
```

```
03692   /* Interpolation... */
03693   else {
03694
03695     /* Get index... */
03696     idx = locate_tbl(tbl->eps[ig][id][ip][it], tbl->nu[ig][id][ip][it], eps);
03697
03698     /* Interpolate... */
03699     return
03700       LIN(tbl->eps[ig][id][ip][it][idx], tbl->u[ig][id][ip][it][idx],
03701           tbl->eps[ig][id][ip][it][idx + 1], tbl->u[ig][id][ip][it][idx + 1],
03702           eps);
03703   }
03704 }
```

Here is the call graph for this function:

5.13.2.26 void jsec2time (double *jsec*, int * *year*, int * *mon*, int * *day*, int * *hour*, int * *min*, int * *sec*, double * *remain*)

Convert seconds to date.

Definition at line 3708 of file jurassic.c.

```
03716                   {
03717
03718   struct tm t0, *t1;
03719
03720   time_t jsec0;
03721
03722   t0.tm_year = 100;
03723   t0.tm_mon = 0;
03724   t0.tm_mday = 1;
03725   t0.tm_hour = 0;
03726   t0.tm_min = 0;
03727   t0.tm_sec = 0;
03728
03729   jsec0 = (time_t) jsec + timegm(&t0);
03730   t1 = gmtime(&jsec0);
03731
03732   *year = t1->tm_year + 1900;
03733   *mon = t1->tm_mon + 1;
03734   *day = t1->tm_mday;
03735   *hour = t1->tm_hour;
03736   *min = t1->tm_min;
03737   *sec = t1->tm_sec;
03738   *remain = jsec - floor(jsec);
03739 }
```

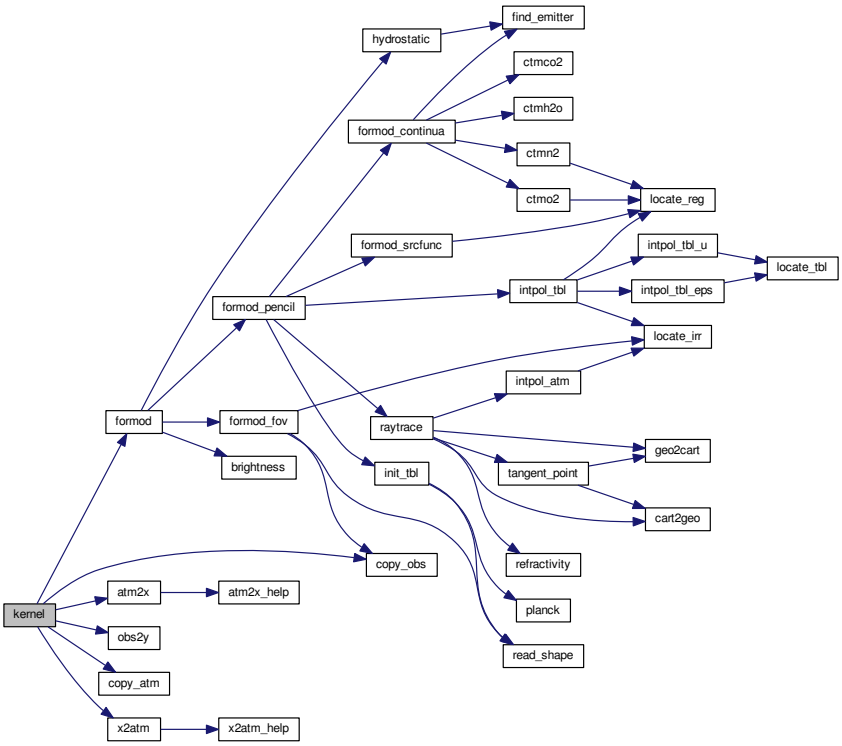
5.13.2.27 void kernel (ctl_t * *ctl*, atm_t * *atm*, obs_t * *obs*, gsl_matrix * *k*)

Compute Jacobians.

Definition at line 3743 of file jurassic.c.

```
03747                   {
03748
03749     atm_t *atm1;
03750     obs_t *obs1;
03751
03752     gsl_vector *x0, *x1, *yy0, *yy1;
03753
03754     int *iqa, j;
03755
03756     double h;
03757
03758     size_t i, n, m;
03759
03760     /* Get sizes... */
03761     m = k->size1;
03762     n = k->size2;
03763
03764     /* Allocate... */
03765     x0 = gsl_vector_alloc(n);
03766     yy0 = gsl_vector_alloc(m);
03767     ALLOC(iqa, int,
03768           N);
03769
03770     /* Compute radiance for undisturbed atmospheric data... */
03771     formod(ctl, atm, obs);
03772
03773     /* Compose vectors... */
03774     atm2x(ctl, atm, x0, iqa, NULL);
03775     obs2y(ctl, obs, yy0, NULL, NULL);
03776
03777     /* Initialize kernel matrix... */
03778     gsl_matrix_set_zero(k);
03779
03780     /* Loop over state vector elements... */
03781 #pragma omp parallel for default(none) shared(ctl,atm,obs,k,x0,yy0,n,m,iqa) private(i, j, h, x1, yy1, atm1,
      obs1)
03782     for (j = 0; j < (int) n; j++) {
03783
03784       /* Allocate... */
03785       x1 = gsl_vector_alloc(n);
03786       yy1 = gsl_vector_alloc(m);
03787       ALLOC(atm1, atm_t, 1);
03788       ALLOC(obs1, obs_t, 1);
03789
03790       /* Set perturbation size... */
03791       if (iqa[j] == IDXP)
03792         h = GSL_MAX(fabs(0.01 * gsl_vector_get(x0, (size_t) j)), 1e-7);
03793       else if (iqa[j] == IDXT)
03794         h = 1;
03795       else if (iqa[j] >= IDXQ(0) && iqa[j] < IDXQ(ctl->ng))
03796         h = GSL_MAX(fabs(0.01 * gsl_vector_get(x0, (size_t) j)), 1e-15);
03797       else if (iqa[j] >= IDXK(0) && iqa[j] < IDXK(ctl->nw))
03798         h = 1e-4;
03799       else
03800         ERRMSG("Cannot set perturbation size!");
03801
03802       /* Disturb state vector element... */
03803       gsl_vector_memcpy(x1, x0);
03804       gsl_vector_set(x1, (size_t) j, gsl_vector_get(x1, (size_t) j) + h);
03805       copy_atm(ctl, atm1, atm, 0);
03806       copy_obs(ctl, obs1, obs, 0);
03807       x2atm(ctl, x1, atm1);
03808
03809       /* Compute radiance for disturbed atmospheric data... */
03810       formod(ctl, atm1, obs1);
03811
03812       /* Compose measurement vector for disturbed radiance data... */
03813       obs2y(ctl, obs1, yy1, NULL, NULL);
03814
03815       /* Compute derivatives... */
03816       for (i = 0; i < m; i++)
03817         gsl_matrix_set(k, i, (size_t) j,
03818                        (gsl_vector_get(yy1, i) - gsl_vector_get(yy0, i)) / h);
03819
03820       /* Free... */
03821       gsl_vector_free(x1);
03822       gsl_vector_free(yy1);
03823       free(atm1);
03824       free(obs1);
03825     }
03826
03827     /* Free... */
03828     gsl_vector_free(x0);
03829     gsl_vector_free(yy0);
03830     free(iqa);
03831 }
```

Here is the call graph for this function:



5.13.2.28 int locate_irr (double * *xx*, int *n*, double *x*)

Find array index for irregular grid.

Definition at line 3835 of file jurassic.c.

```
03838             {
03839
03840   int i, ilo, ihi;
03841
03842   ilo = 0;
03843   ihi = n - 1;
03844   i = (ihi + ilo) >> 1;
03845
03846   if (xx[i] < xx[i + 1])
03847     while (ihi > ilo + 1) {
03848       i = (ihi + ilo) >> 1;
03849       if (xx[i] > x)
03850         ihi = i;
03851       else
03852         ilo = i;
03853   } else
03854     while (ihi > ilo + 1) {
03855       i = (ihi + ilo) >> 1;
03856       if (xx[i] <= x)
03857         ihi = i;
03858       else
03859         ilo = i;
03860     }
03861
03862   return ilo;
03863 }
```

5.13.2.29 int locate_reg (double * xx, int n, double x)

Find array index for regular grid.

Definition at line 3867 of file jurassic.c.

```
03870             {
03871
03872   int i;
03873
03874   /* Calculate index... */
03875   i = (int) ((x - xx[0]) / (xx[1] - xx[0]));
03876
03877   /* Check range... */
03878   if (i < 0)
03879     i = 0;
03880   else if (i >= n - 2)
03881     i = n - 2;
03882
03883   return i;
03884 }
```

5.13.2.30 int locate_tbl (float * xx, int n, double x)

Find array index in float array.

Definition at line 3888 of file jurassic.c.

```
03891             {
03892
03893   int i, ilo, ihi;
03894
03895   ilo = 0;
03896   ihi = n - 1;
03897   i = (ihi + ilo) >> 1;
03898
03899   while (ihi > ilo + 1) {
03900     i = (ihi + ilo) >> 1;
03901     if (xx[i] > x)
03902       ihi = i;
03903     else
03904       ilo = i;
03905   }
03906
03907   return ilo;
03908 }
```

5.13.2.31 size_t obs2y (ctl_t * ctl, obs_t * obs, gsl_vector * y, int * ida, int * ira)

Compose measurement vector.

Definition at line 3912 of file jurassic.c.

```
03917             {
03918
03919   int id, ir;
03920
03921   size_t m = 0;
03922
03923   /* Determine measurement vector... */
03924   for (ir = 0; ir < obs->nr; ir++)
03925     for (id = 0; id < ctl->nd; id++)
03926       if (gsl_finite(obs->rad[id][ir])) {
03927         if (y != NULL)
03928           gsl_vector_set(y, m, obs->rad[id][ir]);
03929         if (ida != NULL)
03930           ida[m] = id;
03931         if (ira != NULL)
03932           ira[m] = ir;
03933         m++;
03934       }
03935
03936   return m;
03937 }
```

5.13.2.32 double planck (double *t*, double *nu*)

Compute Planck function.

Definition at line 3941 of file jurassic.c.

```
03943             {
03944
03945   return C1 * POW3(nu) / gsl_expm1(C2 * nu / t);
03946 }
```

5.13.2.33 void raytrace (ctl_t * *ctl*, atm_t * *atm*, obs_t * *obs*, los_t * *los*, int *ir*)

Do ray-tracing to determine LOS.

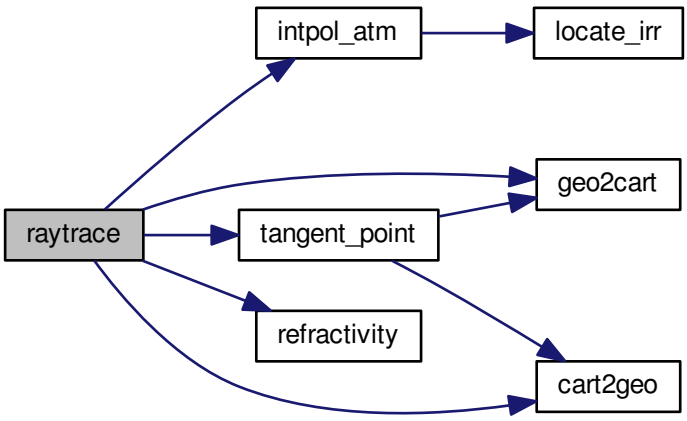
Definition at line 3950 of file jurassic.c.

```
03955           {
03956
03957   double cosa, d, dmax, dmin = 0, ds, ex0[3], ex1[3], frac, h = 0.02, k[NW],
03958     lat, lon, n, naux, ng[3], norm, p, q[NG], t, x[3], xh[3],
03959     xobs[3], xvp[3], z = 1e99, zmax, zmin, zrefrac = 60;
03960
03961   int i, ig, ip, iw, stop = 0;
03962
03963   /* Initialize... */
03964   los->np = 0;
03965   los->tsurf = -999;
03966   obs->tpz[ir] = obs->vpz[ir];
03967   obs->tplon[ir] = obs->vplon[ir];
03968   obs->tplat[ir] = obs->vplat[ir];
03969
03970   /* Get altitude range of atmospheric data... */
03971   gsl_stats_minmax(&zmin, &zmax, atm->z, 1, (size_t) atm->np);
03972
03973   /* Check observer altitude... */
03974   if (obs->obsz[ir] < zmin)
03975     ERRMSG("Observer below surface!");
03976
03977   /* Check view point altitude... */
03978   if (obs->vpz[ir] > zmax)
03979     return;
03980
03981   /* Determine Cartesian coordinates for observer and view point... */
03982   geo2cart(obs->obsz[ir], obs->obslon[ir], obs->obslat[ir], xobs);
03983   geo2cart(obs->vpz[ir], obs->vplon[ir], obs->vplat[ir], xvp);
03984
03985   /* Determine initial tangent vector... */
03986   for (i = 0; i < 3; i++)
03987     ex0[i] = xvp[i] - xobs[i];
03988   norm = NORM(ex0);
03989   for (i = 0; i < 3; i++)
03990     ex0[i] /= norm;
03991
03992   /* Observer within atmosphere... */
03993   for (i = 0; i < 3; i++)
03994     x[i] = xobs[i];
03995
03996   /* Observer above atmosphere (search entry point)... */
03997   if (obs->obsz[ir] > zmax) {
03998     dmax = norm;
03999     while (fabs(dmin - dmax) > 0.001) {
04000       d = (dmax + dmin) / 2;
04001       for (i = 0; i < 3; i++)
04002         x[i] = xobs[i] + d * ex0[i];
04003       cart2geo(x, &z, &lon, &lat);
04004       if (z <= zmax && z > zmax - 0.001)
04005         break;
04006       if (z < zmax - 0.0005)
04007         dmax = d;
04008       else
04009         dmin = d;
04010     }
04011   }
04012
04013   /* Ray-tracing... */
```

```
04014   while (1) {
04015
04016     /* Set step length... */
04017     ds = ctl->rayds;
04018     if (ctl->raydz > 0) {
04019       norm = NORM(x);
04020       for (i = 0; i < 3; i++)
04021         xh[i] = x[i] / norm;
04022       cosa = fabs(DOTP(ex0, xh));
04023       if (cosa != 0)
04024         ds = GSL_MIN(ctl->rayds, ctl->raydz / cosa);
04025     }
04026
04027     /* Determine geolocation... */
04028     cart2geo(x, &z, &lon, &lat);
04029
04030     /* Check if LOS hits the ground or has left atmosphere... */
04031     if (z < zmin || z > zmax) {
04032       stop = (z < zmin ? 2 : 1);
04033       frac =
04034         ((z <
04035           zmin ? zmin : zmax) - los->z[los->np - 1]) / (z - los->z[los->np -
04036                                                                    1]);
04037       geo2cart(los->z[los->np - 1], los->lon[los->np - 1],
04038                los->lat[los->np - 1], xh);
04039       for (i = 0; i < 3; i++)
04040         x[i] = xh[i] + frac * (x[i] - xh[i]);
04041       cart2geo(x, &z, &lon, &lat);
04042       los->ds[los->np - 1] = ds * frac;
04043       ds = 0;
04044     }
04045
04046     /* Interpolate atmospheric data... */
04047     intpol_atm(ctl, atm, z, &p, &t, q, k);
04048
04049     /* Save data... */
04050     los->lon[los->np] = lon;
04051     los->lat[los->np] = lat;
04052     los->z[los->np] = z;
04053     los->p[los->np] = p;
04054     los->t[los->np] = t;
04055     for (ig = 0; ig < ctl->ng; ig++)
04056       los->q[ig][los->np] = q[ig];
04057     for (iw = 0; iw < ctl->nw; iw++)
04058       los->k[iw][los->np] = k[iw];
04059     los->ds[los->np] = ds;
04060
04061     /* Increment and check number of LOS points... */
04062     if ((++los->np) > NLOS)
04063       ERRMSG("Too many LOS points!");
04064
04065     /* Check stop flag... */
04066     if (stop) {
04067       los->tsurf = (stop == 2 ? t : -999);
04068       break;
04069     }
04070
04071     /* Determine refractivity... */
04072     if (ctl->refrac && z <= zrefrac)
04073       n = 1 + refractivity(p, t);
04074     else
04075       n = 1;
04076
04077     /* Construct new tangent vector (first term)... */
04078     for (i = 0; i < 3; i++)
04079       ex1[i] = ex0[i] * n;
04080
04081     /* Compute gradient of refractivity... */
04082     if (ctl->refrac && z <= zrefrac) {
04083       for (i = 0; i < 3; i++)
04084         xh[i] = x[i] + 0.5 * ds * ex0[i];
04085       cart2geo(xh, &z, &lon, &lat);
04086       intpol_atm(ctl, atm, z, &p, &t, q, k);
04087       n = refractivity(p, t);
04088       for (i = 0; i < 3; i++) {
04089         xh[i] += h;
04090         cart2geo(xh, &z, &lon, &lat);
04091         intpol_atm(ctl, atm, z, &p, &t, q, k);
04092         naux = refractivity(p, t);
04093         ng[i] = (naux - n) / h;
04094         xh[i] -= h;
04095       }
04096     } else
04097       for (i = 0; i < 3; i++)
04098         ng[i] = 0;
04099
04100     /* Construct new tangent vector (second term)... */
```

```
04101     for (i = 0; i < 3; i++)
04102       ex1[i] += ds * ng[i];
04103
04104     /* Normalize new tangent vector... */
04105     norm = NORM(ex1);
04106     for (i = 0; i < 3; i++)
04107       ex1[i] /= norm;
04108
04109     /* Determine next point of LOS... */
04110     for (i = 0; i < 3; i++)
04111       x[i] += 0.5 * ds * (ex0[i] + ex1[i]);
04112
04113     /* Copy tangent vector... */
04114     for (i = 0; i < 3; i++)
04115       ex0[i] = ex1[i];
04116   }
04117
04118   /* Get tangent point (to be done before changing segment lengths!)... */
04119   tangent_point(los, &obs->tpz[ir], &obs->tplon[ir], &obs->
      tplat[ir]);
04120
04121   /* Change segment lengths according to trapezoid rule... */
04122   for (ip = los->np - 1; ip >= 1; ip--)
04123     los->ds[ip] = 0.5 * (los->ds[ip - 1] + los->ds[ip]);
04124   los->ds[0] *= 0.5;
04125
04126   /* Compute column density... */
04127   for (ip = 0; ip < los->np; ip++)
04128     for (ig = 0; ig < ctl->ng; ig++)
04129       los->u[ig][ip] = 10 * los->q[ig][ip] * los->p[ip]
04130         / (KB * los->t[ip]) * los->ds[ip];
04131 }
```

Here is the call graph for this function:



5.13.2.34 void read_atm (const char * *dirname*, const char * *filename*, ctl_t * *ctl*, atm_t * *atm*)

Read atmospheric data.

Definition at line 4135 of file jurassic.c.

```
04139               {
04140
04141   FILE *in;
04142
04143   char file[LEN], line[LEN], *tok;
```

```
04144
04145   int ig, iw;
04146
04147   /* Init... */
04148   atm->np = 0;
04149
04150   /* Set filename... */
04151   if (dirname != NULL)
04152     sprintf(file, "%s/%s", dirname, filename);
04153   else
04154     sprintf(file, "%s", filename);
04155
04156   /* Write info... */
04157   printf("Read atmospheric data: %s\n", file);
04158
04159   /* Open file... */
04160   if (!(in = fopen(file, "r")))
04161     ERRMSG("Cannot open file!");
04162
04163   /* Read line... */
04164   while (fgets(line, LEN, in)) {
04165
04166     /* Read data... */
04167     TOK(line, tok, "%lg", atm->time[atm->np]);
04168     TOK(NULL, tok, "%lg", atm->z[atm->np]);
04169     TOK(NULL, tok, "%lg", atm->lon[atm->np]);
04170     TOK(NULL, tok, "%lg", atm->lat[atm->np]);
04171     TOK(NULL, tok, "%lg", atm->p[atm->np]);
04172     TOK(NULL, tok, "%lg", atm->t[atm->np]);
04173     for (ig = 0; ig < ctl->ng; ig++)
04174       TOK(NULL, tok, "%lg", atm->q[ig][atm->np]);
04175     for (iw = 0; iw < ctl->nw; iw++)
04176       TOK(NULL, tok, "%lg", atm->k[iw][atm->np]);
04177
04178     /* Increment data point counter... */
04179     if ((++atm->np) > NP)
04180       ERRMSG("Too many data points!");
04181   }
04182
04183   /* Close file... */
04184   fclose(in);
04185
04186   /* Check number of points... */
04187   if (atm->np < 1)
04188     ERRMSG("Could not read any data!");
04189 }
```

5.13.2.35 void read_ctl (int *argc*, char * *argv[]*, ctl_t * *ctl*)

Read forward model control parameters.

Definition at line 4193 of file jurassic.c.

```
04196               {
04197
04198   int id, ig, iw;
04199
04200   /* Write info... */
04201   printf("\nJuelich Rapid Spectral Simulation Code (JURASSIC)\n"
04202          "(executable: %s | compiled: %s, %s)\n\n",
04203          argv[0], __DATE__, __TIME__);
04204
04205   /* Emitters... */
04206   ctl->ng = (int) scan_ctl(argc, argv, "NG", -1, "0", NULL);
04207   if (ctl->ng < 0 || ctl->ng > NG)
04208     ERRMSG("Set 0 <= NG <= MAX!");
04209   for (ig = 0; ig < ctl->ng; ig++)
04210     scan_ctl(argc, argv, "EMITTER", ig, "", ctl->emitter[ig]);
04211
04212   /* Radiance channels... */
04213   ctl->nd = (int) scan_ctl(argc, argv, "ND", -1, "0", NULL);
04214   if (ctl->nd < 0 || ctl->nd > ND)
04215     ERRMSG("Set 0 <= ND <= MAX!");
04216   for (id = 0; id < ctl->nd; id++)
04217     ctl->nu[id] = scan_ctl(argc, argv, "NU", id, "", NULL);
04218
04219   /* Spectral windows... */
04220   ctl->nw = (int) scan_ctl(argc, argv, "NW", -1, "1", NULL);
04221   if (ctl->nw < 0 || ctl->nw > NW)
04222     ERRMSG("Set 0 <= NW <= MAX!");
```

```
04223   for (id = 0; id < ctl->nd; id++)
04224     ctl->window[id] = (int) scan_ctl(argc, argv, "WINDOW", id, "0", NULL);
04225
04226   /* Emissivity look-up tables... */
04227   scan_ctl(argc, argv, "TBLBASE", -1, "-", ctl->tblbase);
04228
04229   /* Hydrostatic equilibrium... */
04230   ctl->hydz = scan_ctl(argc, argv, "HYDZ", -1, "-999", NULL);
04231
04232   /* Continua... */
04233   ctl->ctm_co2 = (int) scan_ctl(argc, argv, "CTM_CO2", -1, "1", NULL);
04234   ctl->ctm_h2o = (int) scan_ctl(argc, argv, "CTM_H2O", -1, "1", NULL);
04235   ctl->ctm_n2 = (int) scan_ctl(argc, argv, "CTM_N2", -1, "1", NULL);
04236   ctl->ctm_o2 = (int) scan_ctl(argc, argv, "CTM_O2", -1, "1", NULL);
04237
04238   /* Ray-tracing... */
04239   ctl->refrac = (int) scan_ctl(argc, argv, "REFRAC", -1, "1", NULL);
04240   ctl->rayds = scan_ctl(argc, argv, "RAYDS", -1, "10", NULL);
04241   ctl->raydz = scan_ctl(argc, argv, "RAYDZ", -1, "0.5", NULL);
04242
04243   /* Field of view... */
04244   scan_ctl(argc, argv, "FOV", -1, "-", ctl->fov);
04245
04246   /* Retrieval interface... */
04247   ctl->retp_zmin = scan_ctl(argc, argv, "RETP_ZMIN", -1, "-999", NULL);
04248   ctl->retp_zmax = scan_ctl(argc, argv, "RETP_ZMAX", -1, "-999", NULL);
04249   ctl->rett_zmin = scan_ctl(argc, argv, "RETT_ZMIN", -1, "-999", NULL);
04250   ctl->rett_zmax = scan_ctl(argc, argv, "RETT_ZMAX", -1, "-999", NULL);
04251   for (ig = 0; ig < ctl->ng; ig++) {
04252     ctl->retq_zmin[ig] = scan_ctl(argc, argv, "RETQ_ZMIN", ig, "-999", NULL);
04253     ctl->retq_zmax[ig] = scan_ctl(argc, argv, "RETQ_ZMAX", ig, "-999", NULL);
04254   }
04255   for (iw = 0; iw < ctl->nw; iw++) {
04256     ctl->retk_zmin[iw] = scan_ctl(argc, argv, "RETK_ZMIN", iw, "-999", NULL);
04257     ctl->retk_zmax[iw] = scan_ctl(argc, argv, "RETK_ZMAX", iw, "-999", NULL);
04258   }
04259
04260   /* Output flags... */
04261   ctl->write_bbt = (int) scan_ctl(argc, argv, "WRITE_BBT", -1, "0", NULL);
04262   ctl->write_matrix =
04263     (int) scan_ctl(argc, argv, "WRITE_MATRIX", -1, "0", NULL);
04264 }
```

Here is the call graph for this function:

5.13.2.36 void read_matrix (const char * *dirname*, const char * *filename*, gsl_matrix * *matrix*)

Read matrix.

Definition at line 4268 of file jurassic.c.

```
04271                         {
04272
04273   FILE *in;
04274
04275   char dum[LEN], file[LEN], line[LEN];
04276
04277   double value;
04278
04279   int i, j;
04280
04281   /* Set filename... */
```

```
04282   if (dirname != NULL)
04283     sprintf(file, "%s/%s", dirname, filename);
04284   else
04285     sprintf(file, "%s", filename);
04286
04287   /* Write info... */
04288   printf("Read matrix: %s\n", file);
04289
04290   /* Open file... */
04291   if (!(in = fopen(file, "r")))
04292     ERRMSG("Cannot open file!");
04293
04294   /* Read data... */
04295   gsl_matrix_set_zero(matrix);
04296   while (fgets(line, LEN, in))
04297     if (sscanf(line, "%d %s %s %s %s %s %d %s %s %s %s %s %lg",
04298                &i, dum, dum, dum, dum, dum,
04299                &j, dum, dum, dum, dum, dum, &value) == 13)
04300       gsl_matrix_set(matrix, (size_t) i, (size_t) j, value);
04301
04302   /* Close file... */
04303   fclose(in);
04304 }
```

5.13.2.37 void read_obs (const char * *dirname*, const char * *filename*, ctl_t * *ctl*, obs_t * *obs*)

Read observation data.

Definition at line 4308 of file jurassic.c.

```
04312                {
04313
04314   FILE *in;
04315
04316   char file[LEN], line[LEN], *tok;
04317
04318   int id;
04319
04320   /* Init... */
04321   obs->nr = 0;
04322
04323   /* Set filename... */
04324   if (dirname != NULL)
04325     sprintf(file, "%s/%s", dirname, filename);
04326   else
04327     sprintf(file, "%s", filename);
04328
04329   /* Write info... */
04330   printf("Read observation data: %s\n", file);
04331
04332   /* Open file... */
04333   if (!(in = fopen(file, "r")))
04334     ERRMSG("Cannot open file!");
04335
04336   /* Read line... */
04337   while (fgets(line, LEN, in)) {
04338
04339     /* Read data... */
04340     TOK(line, tok, "%lg", obs->time[obs->nr]);
04341     TOK(NULL, tok, "%lg", obs->obsz[obs->nr]);
04342     TOK(NULL, tok, "%lg", obs->obslon[obs->nr]);
04343     TOK(NULL, tok, "%lg", obs->obslat[obs->nr]);
04344     TOK(NULL, tok, "%lg", obs->vpz[obs->nr]);
04345     TOK(NULL, tok, "%lg", obs->vplon[obs->nr]);
04346     TOK(NULL, tok, "%lg", obs->vplat[obs->nr]);
04347     TOK(NULL, tok, "%lg", obs->tpz[obs->nr]);
04348     TOK(NULL, tok, "%lg", obs->tplon[obs->nr]);
04349     TOK(NULL, tok, "%lg", obs->tplat[obs->nr]);
04350     for (id = 0; id < ctl->nd; id++)
04351       TOK(NULL, tok, "%lg", obs->rad[id][obs->nr]);
04352     for (id = 0; id < ctl->nd; id++)
04353       TOK(NULL, tok, "%lg", obs->tau[id][obs->nr]);
04354
04355     /* Increment counter... */
04356     if ((++obs->nr) > NR)
04357       ERRMSG("Too many rays!");
04358   }
04359
04360   /* Close file... */
04361   fclose(in);
```

```
04362
04363   /* Check number of points... */
04364   if (obs->nr < 1)
04365     ERRMSG("Could not read any data!");
04366 }
```

5.13.2.38 void read_shape (const char * *filename*, double * *x*, double * *y*, int * *n*)

Read shape function.

Definition at line 4370 of file jurassic.c.

```
04374           {
04375
04376   FILE *in;
04377
04378   char line[LEN];
04379
04380   /* Write info... */
04381   printf("Read shape function: %s\n", filename);
04382
04383   /* Open file... */
04384   if (!(in = fopen(filename, "r")))
04385     ERRMSG("Cannot open file!");
04386
04387   /* Read data... */
04388   *n = 0;
04389   while (fgets(line, LEN, in))
04390     if (sscanf(line, "%lg %lg", &x[*n], &y[*n]) == 2)
04391       if ((++(*n)) > NSHAPE)
04392         ERRMSG("Too many data points!");
04393
04394   /* Check number of points... */
04395   if (*n < 1)
04396     ERRMSG("Could not read any data!");
04397
04398   /* Close file... */
04399   fclose(in);
04400 }
```

5.13.2.39 double refractivity (double *p*, double *t*)

Compute refractivity (return value is n - 1).

Definition at line 4404 of file jurassic.c.

```
04406             {
04407
04408   /* Refractivity of air at 4 to 15 micron... */
04409   return 7.753e-05 * p / t;
04410 }
```

5.13.2.40 double scan_ctl (int *argc*, char * *argv[]*, const char * *varname*, int *arridx*, const char * *defvalue*, char * *value*)

Search control parameter file for variable entry.

Definition at line 4414 of file jurassic.c.

```
04420               {
04421
04422   FILE *in = NULL;
04423
04424   char dummy[LEN], fullname1[LEN], fullname2[LEN], line[LEN],
04425     msg[2 * LEN], rvarname[LEN], rval[LEN];
04426
04427   int contain = 0, i;
04428
04429   /* Open file... */
04430   if (argv[1][0] != '-')
04431     if (!(in = fopen(argv[1], "r")))
04432       ERRMSG("Cannot open file!");
04433
04434   /* Set full variable name... */
04435   if (arridx >= 0) {
04436     sprintf(fullname1, "%s[%d]", varname, arridx);
04437     sprintf(fullname2, "%s[*]", varname);
04438   } else {
04439     sprintf(fullname1, "%s", varname);
04440     sprintf(fullname2, "%s", varname);
04441   }
04442
04443   /* Read data... */
04444   if (in != NULL)
04445     while (fgets(line, LEN, in))
04446       if (sscanf(line, "%s %s %s", rvarname, dummy, rval) == 3)
04447         if (strcasecmp(rvarname, fullname1) == 0 ||
04448             strcasecmp(rvarname, fullname2) == 0) {
04449           contain = 1;
04450           break;
04451         }
04452   for (i = 1; i < argc - 1; i++)
04453     if (strcasecmp(argv[i], fullname1) == 0 ||
04454         strcasecmp(argv[i], fullname2) == 0) {
04455       sprintf(rval, "%s", argv[i + 1]);
04456       contain = 1;
04457       break;
04458     }
04459
04460   /* Close file... */
04461   if (in != NULL)
04462     fclose(in);
04463
04464   /* Check for missing variables... */
04465   if (!contain) {
04466     if (strlen(defvalue) > 0)
04467       sprintf(rval, "%s", defvalue);
04468     else {
04469       sprintf(msg, "Missing variable %s!\n", fullname1);
04470       ERRMSG(msg);
04471     }
04472   }
04473
04474   /* Write info... */
04475   printf("%s = %s\n", fullname1, rval);
04476
04477   /* Return values... */
04478   if (value != NULL)
04479     sprintf(value, "%s", rval);
04480   return atof(rval);
04481 }
```

5.13.2.41 void tangent_point (los_t * *los*, double * *tpz*, double * *tplon*, double * *tplat*)

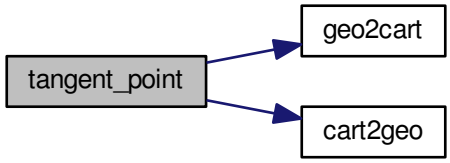
Find tangent point of a given LOS.

Definition at line 4485 of file jurassic.c.

```
04489               {
04490
04491   double a, b, c, dummy, v[3], v0[3], v2[3], x, x1, x2, yy0, yy1, yy2;
04492
04493   size_t i, ip;
04494
04495   /* Find minimum altitude... */
04496   ip = gsl_stats_min_index(los->z, 1, (size_t) los->np);
04497
04498   /* Nadir or zenith... */
04499   if (ip <= 0 || ip >= (size_t) los->np - 1) {
```

```
04500     *tpz = los->z[los->np - 1];
04501     *tplon = los->lon[los->np - 1];
04502     *tplat = los->lat[los->np - 1];
04503   }
04504
04505   /* Limb... */
04506   else {
04507
04508     /* Determine interpolating polynomial y=a*x^2+b*x+c... */
04509     yy0 = los->z[ip - 1];
04510     yy1 = los->z[ip];
04511     yy2 = los->z[ip + 1];
04512     x1 = sqrt(POW2(los->ds[ip]) - POW2(yy1 - yy0));
04513     x2 = x1 + sqrt(POW2(los->ds[ip + 1]) - POW2(yy2 - yy1));
04514     a = 1 / (x1 - x2) * (-(yy0 - yy1) / x1 + (yy0 - yy2) / x2);
04515     b = -(yy0 - yy1) / x1 - a * x1;
04516     c = yy0;
04517
04518     /* Get tangent point location... */
04519     x = -b / (2 * a);
04520     *tpz = a * x * x + b * x + c;
04521     geo2cart(los->z[ip - 1], los->lon[ip - 1], los->lat[ip - 1], v0);
04522     geo2cart(los->z[ip + 1], los->lon[ip + 1], los->lat[ip + 1], v2);
04523     for (i = 0; i < 3; i++)
04524       v[i] = LIN(0.0, v0[i], x2, v2[i], x);
04525     cart2geo(v, &dummy, tplon, tplat);
04526   }
04527 }
```

Here is the call graph for this function:



5.13.2.42 void time2jsec (int *year*, int *mon*, int *day*, int *hour*, int *min*, int *sec*, double *remain*, double * *jsec*)

Convert date to seconds.

Definition at line 4531 of file jurassic.c.

```
04539                 {
04540
04541   struct tm t0, t1;
04542
04543   t0.tm_year = 100;
04544   t0.tm_mon = 0;
04545   t0.tm_mday = 1;
04546   t0.tm_hour = 0;
04547   t0.tm_min = 0;
04548   t0.tm_sec = 0;
04549
04550   t1.tm_year = year - 1900;
04551   t1.tm_mon = mon - 1;
04552   t1.tm_mday = day;
04553   t1.tm_hour = hour;
04554   t1.tm_min = min;
04555   t1.tm_sec = sec;
04556
04557   *jsec = (double) timegm(&t1) - (double) timegm(&t0) + remain;
04558 }
```

5.13.2.43 void timer (const char * *name*, const char * *file*, const char * *func*, int *line*, int *mode*)

Measure wall-clock time.

Definition at line 4562 of file jurassic.c.

```
04567            {
04568
04569   static double w0[10];
04570
04571   static int l0[10], nt;
04572
04573   /* Start new timer... */
04574   if (mode == 1) {
04575     w0[nt] = omp_get_wtime();
04576     l0[nt] = line;
04577     if ((++nt) >= 10)
04578       ERRMSG("Too many timers!");
04579   }
04580
04581   /* Write elapsed time... */
04582   else {
04583
04584     /* Check timer index... */
04585     if (nt - 1 < 0)
04586       ERRMSG("Coding error!");
04587
04588     /* Write elapsed time... */
04589     printf("Timer '%s' (%s, %s, l%d-%d): %.3f sec\n",
04590            name, file, func, l0[nt - 1], line, omp_get_wtime() - w0[nt - 1]);
04591   }
04592
04593   /* Stop timer... */
04594   if (mode == 3)
04595     nt--;
04596 }
```

5.13.2.44 void write_atm (const char * *dirname*, const char * *filename*, ctl_t * *ctl*, atm_t * *atm*)

Write atmospheric data.

Definition at line 4600 of file jurassic.c.

```
04604               {
04605
04606   FILE *out;
04607
04608   char file[LEN];
04609
04610   int ig, ip, iw, n = 6;
04611
04612   /* Set filename... */
04613   if (dirname != NULL)
04614     sprintf(file, "%s/%s", dirname, filename);
04615   else
04616     sprintf(file, "%s", filename);
04617
04618   /* Write info... */
04619   printf("Write atmospheric data: %s\n", file);
04620
04621   /* Create file... */
04622   if (!(out = fopen(file, "w")))
04623     ERRMSG("Cannot create file!");
04624
04625   /* Write header... */
04626   fprintf(out,
04627           "# $1 = time (seconds since 2000-01-01T00:00Z)\n"
04628           "# $2 = altitude [km]\n"
04629           "# $3 = longitude [deg]\n"
04630           "# $4 = latitude [deg]\n"
04631           "# $5 = pressure [hPa]\n" "# $6 = temperature [K]\n");
04632   for (ig = 0; ig < ctl->ng; ig++)
04633     fprintf(out, "# $%d = %s volume mixing ratio\n", ++n, ctl->emitter[ig]);
04634   for (iw = 0; iw < ctl->nw; iw++)
04635     fprintf(out, "# $%d = window %d: extinction [1/km]\n", ++n, iw);
04636
```

```
04637   /* Write data... */
04638   for (ip = 0; ip < atm->np; ip++) {
04639     if (ip == 0 || atm->lat[ip] != atm->lat[ip - 1]
04640         || atm->lon[ip] != atm->lon[ip - 1])
04641       fprintf(out, "\n");
04642     fprintf(out, "%.2f %g %g %g %g %g", atm->time[ip], atm->z[ip],
04643             atm->lon[ip], atm->lat[ip], atm->p[ip], atm->t[ip]);
04644     for (ig = 0; ig < ctl->ng; ig++)
04645       fprintf(out, " %g", atm->q[ig][ip]);
04646     for (iw = 0; iw < ctl->nw; iw++)
04647       fprintf(out, " %g", atm->k[iw][ip]);
04648     fprintf(out, "\n");
04649   }
04650
04651   /* Close file... */
04652   fclose(out);
04653 }
```

5.13.2.45 void write_matrix (const char * *dirname*, const char * *filename*, ctl_t * *ctl*, gsl_matrix * *matrix*, atm_t * *atm*, obs_t * *obs*, const char * *rowspace*, const char * *colspace*, const char * *sort*)

Write matrix.

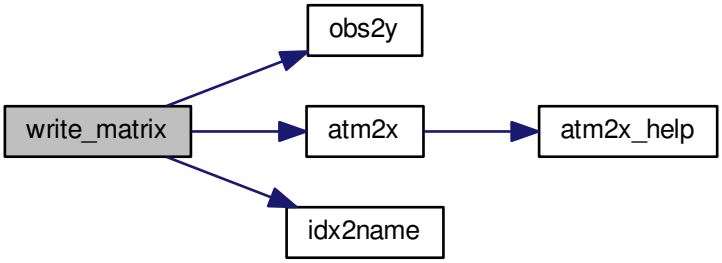
Definition at line 4657 of file jurassic.c.

```
04666                   {
04667
04668   FILE *out;
04669
04670   char file[LEN], quantity[LEN];
04671
04672   int *cida, *ciqa, *cipa, *cira, *rida, *riqa, *ripa, *rira;
04673
04674   size_t i, j, nc, nr;
04675
04676   /* Check output flag... */
04677   if (!ctl->write_matrix)
04678     return;
04679
04680   /* Allocate... */
04681   ALLOC(cida, int, M);
04682   ALLOC(ciqa, int,
04683         N);
04684   ALLOC(cipa, int,
04685         N);
04686   ALLOC(cira, int,
04687         M);
04688   ALLOC(rida, int,
04689         M);
04690   ALLOC(riqa, int,
04691         N);
04692   ALLOC(ripa, int,
04693         N);
04694   ALLOC(rira, int,
04695         M);
04696
04697   /* Set filename... */
04698   if (dirname != NULL)
04699     sprintf(file, "%s/%s", dirname, filename);
04700   else
04701     sprintf(file, "%s", filename);
04702
04703   /* Write info... */
04704   printf("Write matrix: %s\n", file);
04705
04706   /* Create file... */
04707   if (!(out = fopen(file, "w")))
04708     ERRMSG("Cannot create file!");
04709
04710   /* Write header (row space)... */
04711   if (rowspace[0] == 'y') {
04712
04713     fprintf(out,
04714             "# $1 = Row: index (measurement space)\n"
04715             "# $2 = Row: channel wavenumber [cm^-1]\n"
04716             "# $3 = Row: time (seconds since 2000-01-01T00:00Z)\n"
04717             "# $4 = Row: view point altitude [km]\n"
04718             "# $5 = Row: view point longitude [deg]\n"
04719             "# $6 = Row: view point latitude [deg]\n");
04720
```

```
04721     /* Get number of rows... */
04722     nr = obs2y(ctl, obs, NULL, rida, rira);
04723
04724   } else {
04725
04726     fprintf(out,
04727             "# $1 = Row: index (state space)\n"
04728             "# $2 = Row: name of quantity\n"
04729             "# $3 = Row: time (seconds since 2000-01-01T00:00Z)\n"
04730             "# $4 = Row: altitude [km]\n"
04731             "# $5 = Row: longitude [deg]\n" "# $6 = Row: latitude [deg]\n");
04732
04733     /* Get number of rows... */
04734     nr = atm2x(ctl, atm, NULL, riqa, ripa);
04735   }
04736
04737   /* Write header (column space)... */
04738   if (colspace[0] == 'y') {
04739
04740     fprintf(out,
04741             "# $7 = Col: index (measurement space)\n"
04742             "# $8 = Col: channel wavenumber [cm^-1]\n"
04743             "# $9 = Col: time (seconds since 2000-01-01T00:00Z)\n"
04744             "# $10 = Col: view point altitude [km]\n"
04745             "# $11 = Col: view point longitude [deg]\n"
04746             "# $12 = Col: view point latitude [deg]\n");
04747
04748     /* Get number of columns... */
04749     nc = obs2y(ctl, obs, NULL, cida, cira);
04750
04751   } else {
04752
04753     fprintf(out,
04754             "# $7 = Col: index (state space)\n"
04755             "# $8 = Col: name of quantity\n"
04756             "# $9 = Col: time (seconds since 2000-01-01T00:00Z)\n"
04757             "# $10 = Col: altitude [km]\n"
04758             "# $11 = Col: longitude [deg]\n" "# $12 = Col: latitude [deg]\n");
04759
04760     /* Get number of columns... */
04761     nc = atm2x(ctl, atm, NULL, ciqa, cipa);
04762   }
04763
04764   /* Write header entry... */
04765   fprintf(out, "# $13 = Matrix element\n\n");
04766
04767   /* Write matrix data... */
04768   i = j = 0;
04769   while (i < nr && j < nc) {
04770
04771     /* Write info about the row... */
04772     if (rowspace[0] == 'y')
04773       fprintf(out, "%d %g %.2f %g %g %g",
04774               (int) i, ctl->nu[rida[i]],
04775               obs->time[rira[i]], obs->vpz[rira[i]],
04776               obs->vplon[rira[i]], obs->vplat[rira[i]]);
04777     else {
04778       idx2name(ctl, riqa[i], quantity);
04779       fprintf(out, "%d %s %.2f %g %g %g", (int) i, quantity,
04780               atm->time[ripa[i]], atm->z[ripa[i]],
04781               atm->lon[ripa[i]], atm->lat[ripa[i]]);
04782     }
04783
04784     /* Write info about the column... */
04785     if (colspace[0] == 'y')
04786       fprintf(out, " %d %g %.2f %g %g %g",
04787               (int) j, ctl->nu[cida[j]],
04788               obs->time[cira[j]], obs->vpz[cira[j]],
04789               obs->vplon[cira[j]], obs->vplat[cira[j]]);
04790     else {
04791       idx2name(ctl, ciqa[j], quantity);
04792       fprintf(out, " %d %s %.2f %g %g %g", (int) j, quantity,
04793               atm->time[cipa[j]], atm->z[cipa[j]],
04794               atm->lon[cipa[j]], atm->lat[cipa[j]]);
04795     }
04796
04797     /* Write matrix entry... */
04798     fprintf(out, " %g\n", gsl_matrix_get(matrix, i, j));
04799
04800     /* Set matrix indices... */
04801     if (sort[0] == 'r') {
04802       j++;
04803       if (j >= nc) {
04804         j = 0;
04805         i++;
04806         fprintf(out, "\n");
04807       }
```

```
04808     } else {
04809       i++;
04810       if (i >= nr) {
04811         i = 0;
04812         j++;
04813         fprintf(out, "\n");
04814       }
04815     }
04816   }
04817
04818   /* Close file... */
04819   fclose(out);
04820
04821   /* Free... */
04822   free(cida);
04823   free(ciqa);
04824   free(cipa);
04825   free(cira);
04826   free(rida);
04827   free(riqa);
04828   free(ripa);
04829   free(rira);
04830 }
```

Here is the call graph for this function:



5.13.2.46 void write_obs (const char * *dirname*, const char * *filename*, ctl_t * *ctl*, obs_t * *obs*)

Write observation data.

Definition at line 4834 of file jurassic.c.

```
04838                {
04839
04840   FILE *out;
04841
04842   char file[LEN];
04843
04844   int id, ir, n = 10;
04845
04846   /* Set filename... */
04847   if (dirname != NULL)
04848     sprintf(file, "%s/%s", dirname, filename);
04849   else
04850     sprintf(file, "%s", filename);
04851
04852   /* Write info... */
04853   printf("Write observation data: %s\n", file);
04854
04855   /* Create file... */
04856   if (!(out = fopen(file, "w")))
04857     ERRMSG("Cannot create file!");
04858
```

```
04859   /* Write header... */
04860   fprintf(out,
04861           "# $1 = time (seconds since 2000-01-01T00:00Z)\n"
04862           "# $2 = observer altitude [km]\n"
04863           "# $3 = observer longitude [deg]\n"
04864           "# $4 = observer latitude [deg]\n"
04865           "# $5 = view point altitude [km]\n"
04866           "# $6 = view point longitude [deg]\n"
04867           "# $7 = view point latitude [deg]\n"
04868           "# $8 = tangent point altitude [km]\n"
04869           "# $9 = tangent point longitude [deg]\n"
04870           "# $10 = tangent point latitude [deg]\n");
04871   for (id = 0; id < ctl->nd; id++)
04872     fprintf(out, "# $%d = channel %g: radiance [W/(m^2 sr cm^-1)]\n",
04873             ++n, ctl->nu[id]);
04874   for (id = 0; id < ctl->nd; id++)
04875     fprintf(out, "# $%d = channel %g: transmittance\n", ++n, ctl->nu[id]);
04876
04877   /* Write data... */
04878   for (ir = 0; ir < obs->nr; ir++) {
04879     if (ir == 0 || obs->time[ir] != obs->time[ir - 1])
04880       fprintf(out, "\n");
04881     fprintf(out, "%.2f %g %g %g %g %g %g %g %g %g", obs->time[ir],
04882             obs->obsz[ir], obs->obslon[ir], obs->obslat[ir],
04883             obs->vpz[ir], obs->vplon[ir], obs->vplat[ir],
04884             obs->tpz[ir], obs->tplon[ir], obs->tplat[ir]);
04885     for (id = 0; id < ctl->nd; id++)
04886       fprintf(out, " %g", obs->rad[id][ir]);
04887     for (id = 0; id < ctl->nd; id++)
04888       fprintf(out, " %g", obs->tau[id][ir]);
04889     fprintf(out, "\n");
04890   }
04891
04892   /* Close file... */
04893   fclose(out);
04894 }
```

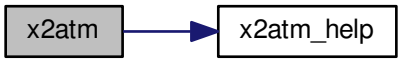
5.13.2.47 void x2atm (ctl_t * *ctl*, gsl_vector * *x*, atm_t * *atm*)

Decompose parameter vector or state vector.

Definition at line 4898 of file jurassic.c.

```
04901               {
04902
04903   int ig, iw;
04904
04905   size_t n = 0;
04906
04907   /* Set pressure... */
04908   x2atm_help(atm, ctl->retp_zmin, ctl->retp_zmax, atm->
      p, x, &n);
04909
04910   /* Set temperature... */
04911   x2atm_help(atm, ctl->rett_zmin, ctl->rett_zmax, atm->
      t, x, &n);
04912
04913   /* Set volume mixing ratio... */
04914   for (ig = 0; ig < ctl->ng; ig++)
04915     x2atm_help(atm, ctl->retq_zmin[ig], ctl->retq_zmax[ig],
04916                atm->q[ig], x, &n);
04917
04918   /* Set extinction... */
04919   for (iw = 0; iw < ctl->nw; iw++)
04920     x2atm_help(atm, ctl->retk_zmin[iw], ctl->retk_zmax[iw],
04921                atm->k[iw], x, &n);
04922 }
```

Here is the call graph for this function:



5.13.2.48 void x2atm_help (atm_t * *atm*, double *zmin*, double *zmax*, double * *value*, gsl_vector * *x*, size_t * *n*)

Extract elements from state vector.

Definition at line 4926 of file jurassic.c.

```
04932               {
04933
04934   int ip;
04935
04936   /* Extract state vector elements... */
04937   for (ip = 0; ip < atm->np; ip++)
04938     if (atm->z[ip] >= zmin && atm->z[ip] <= zmax) {
04939       value[ip] = gsl_vector_get(x, *n);
04940       (*n)++;
04941     }
04942 }
```

5.13.2.49 void y2obs (ctl_t * *ctl*, gsl_vector * *y*, obs_t * *obs*)

Decompose measurement vector.

Definition at line 4946 of file jurassic.c.

```
04949                {
04950
04951   int id, ir;
04952
04953   size_t m = 0;
04954
04955   /* Decompose measurement vector... */
04956   for (ir = 0; ir < obs->nr; ir++)
04957     for (id = 0; id < ctl->nd; id++)
04958       if (gsl_finite(obs->rad[id][ir])) {
04959         obs->rad[id][ir] = gsl_vector_get(y, m);
04960         m++;
04961       }
04962 }
```

5.14 jurassic.c

```
00001 /*
00002   This file is part of JURASSIC.
00003
00004   JURASSIC is free software: you can redistribute it and/or modify
00005   it under the terms of the GNU General Public License as published by
00006   the Free Software Foundation, either version 3 of the License, or
00007   (at your option) any later version.
00008
00009   JURASSIC is distributed in the hope that it will be useful,
00010   but WITHOUT ANY WARRANTY; without even the implied warranty of
00011   MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.  See the
00012   GNU General Public License for more details.
00013
00014   You should have received a copy of the GNU General Public License
00015   along with JURASSIC. If not, see <http://www.gnu.org/licenses/>.
00016
00017   Copyright (C) 2003-2015 Forschungszentrum Juelich GmbH
00018 */
00019
00025 #include "jurassic.h"
00026
00027 /*****************************************************************************/
00028
00029 size_t atm2x(
00030   ctl_t * ctl,
00031   atm_t * atm,
00032   gsl_vector * x,
00033   int *iqa,
00034   int *ipa) {
00035
00036   int ig, iw;
```

```
00037
00038   size_t n = 0;
00039
00040   /* Add pressure... */
00041   atm2x_help(atm, ctl->retp_zmin, ctl->retp_zmax,
00042              atm->p, IDXP, x, iqa, ipa, &n);
00043
00044   /* Add temperature... */
00045   atm2x_help(atm, ctl->rett_zmin, ctl->rett_zmax,
00046              atm->t, IDXT, x, iqa, ipa, &n);
00047
00048   /* Add volume mixing ratios... */
00049   for (ig = 0; ig < ctl->ng; ig++)
00050     atm2x_help(atm, ctl->retq_zmin[ig], ctl->retq_zmax[ig],
00051                atm->q[ig], IDXQ(ig), x, iqa, ipa, &n);
00052
00053   /* Add extinction... */
00054   for (iw = 0; iw < ctl->nw; iw++)
00055     atm2x_help(atm, ctl->retk_zmin[iw], ctl->retk_zmax[iw],
00056                atm->k[iw], IDXK(iw), x, iqa, ipa, &n);
00057
00058   return n;
00059 }
00060
00061 /*****************************************************************************/
00062
00063 void atm2x_help(
00064   atm_t * atm,
00065   double zmin,
00066   double zmax,
00067   double *value,
00068   int val_iqa,
00069   gsl_vector * x,
00070   int *iqa,
00071   int *ipa,
00072   size_t * n) {
00073
00074   int ip;
00075
00076   /* Add elements to state vector... */
00077   for (ip = 0; ip < atm->np; ip++)
00078     if (atm->z[ip] >= zmin && atm->z[ip] <= zmax) {
00079       if (x != NULL)
00080         gsl_vector_set(x, *n, value[ip]);
00081       if (iqa != NULL)
00082         iqa[*n] = val_iqa;
00083       if (ipa != NULL)
00084         ipa[*n] = ip;
00085       (*n)++;
00086     }
00087 }
00088
00089 /*****************************************************************************/
00090
00091 double brightness(
00092   double rad,
00093   double nu) {
00094
00095   return C2 * nu / gsl_log1p(C1 * POW3(nu) / rad);
00096 }
00097
00098
00099 /*****************************************************************************/
00100
00101 void cart2geo(
00102   double *x,
00103   double *z,
00104   double *lon,
00105   double *lat) {
00106
00107   double radius;
00108
00109   radius = NORM(x);
00110   *lat = asin(x[2] / radius) * 180 / M_PI;
00111   *lon = atan2(x[1], x[0]) * 180 / M_PI;
00112   *z = radius - RE;
00113 }
00114
00115 /*****************************************************************************/
00116
00117 void climatology(
00118   ctl_t * ctl,
00119   atm_t * atm) {
00120
00121   static double z[121] = {
00122     0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,
00123     20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37,
```

```
00124     38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55,
00125     56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73,
00126     74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91,
00127     92, 93, 94, 95, 96, 97, 98, 99, 100, 101, 102, 103, 104, 105, 106, 107,
00128     108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 119, 120
00129   };
00130
00131   static double pre[121] = {
00132     1017, 901.083, 796.45, 702.227, 617.614, 541.644, 473.437, 412.288,
00133     357.603, 308.96, 265.994, 228.348, 195.619, 167.351, 143.039, 122.198,
00134     104.369, 89.141, 76.1528, 65.0804, 55.641, 47.591, 40.7233, 34.8637,
00135     29.8633, 25.5956, 21.9534, 18.8445, 16.1909, 13.9258, 11.9913,
00136     10.34, 8.92988, 7.72454, 6.6924, 5.80701, 5.04654, 4.39238, 3.82902,
00137     3.34337, 2.92413, 2.56128, 2.2464, 1.97258, 1.73384, 1.52519, 1.34242,
00138     1.18197, 1.04086, 0.916546, 0.806832, 0.709875, 0.624101, 0.548176,
00139     0.480974, 0.421507, 0.368904, 0.322408, 0.281386, 0.245249, 0.213465,
00140     0.185549, 0.161072, 0.139644, 0.120913, 0.104568, 0.0903249, 0.0779269,
00141     0.0671493, 0.0577962, 0.0496902, 0.0426736, 0.0366093, 0.0313743,
00142     0.0268598, 0.0229699, 0.0196206, 0.0167399, 0.0142646, 0.0121397,
00143     0.0103181, 0.00875775, 0.00742226, 0.00628076, 0.00530519, 0.00447183,
00144     0.00376124, 0.00315632, 0.00264248, 0.00220738, 0.00184003, 0.00153095,
00145     0.00127204, 0.00105608, 0.000876652, 0.00072798, 0.00060492,
00146     0.000503201, 0.000419226, 0.000349896, 0.000292659, 0.000245421,
00147     0.000206394, 0.000174125, 0.000147441, 0.000125333, 0.000106985,
00148     9.173e-05, 7.90172e-05, 6.84172e-05, 5.95574e-05, 5.21183e-05,
00149     4.58348e-05, 4.05127e-05, 3.59987e-05, 3.21583e-05, 2.88718e-05,
00150     2.60322e-05, 2.35687e-05, 2.14263e-05, 1.95489e-05
00151   };
00152
00153   static double tem[121] = {
00154     285.14, 279.34, 273.91, 268.3, 263.24, 256.55, 250.2, 242.82, 236.17,
00155     229.87, 225.04, 221.19, 218.85, 217.19, 216.2, 215.68, 215.42, 215.55,
00156     215.92, 216.4, 216.93, 217.45, 218, 218.68, 219.39, 220.25, 221.3,
00157     222.41, 223.88, 225.42, 227.2, 229.52, 231.89, 234.51, 236.85, 239.42,
00158     241.94, 244.57, 247.36, 250.32, 253.34, 255.82, 258.27, 260.39,
00159     262.03, 263.45, 264.2, 264.78, 264.67, 264.38, 263.24, 262.03, 260.02,
00160     258.09, 255.63, 253.28, 250.43, 247.81, 245.26, 242.77, 240.38,
00161     237.94, 235.79, 233.53, 231.5, 229.53, 227.6, 225.62, 223.77, 222.06,
00162     220.33, 218.69, 217.18, 215.64, 214.13, 212.52, 210.86, 209.25,
00163     207.49, 205.81, 204.11, 202.22, 200.32, 198.39, 195.92, 193.46,
00164     190.94, 188.31, 185.82, 183.57, 181.43, 179.74, 178.64, 178.1, 178.25,
00165     178.7, 179.41, 180.67, 182.31, 184.18, 186.6, 189.53, 192.66, 196.54,
00166     201.13, 205.93, 211.73, 217.86, 225, 233.53, 242.57, 252.14, 261.48,
00167     272.97, 285.26, 299.12, 312.2, 324.17, 338.34, 352.56, 365.28
00168   };
00169
00170   static double c2h2[121] = {
00171     1.352e-09, 2.83e-10, 1.269e-10, 6.926e-11, 4.346e-11, 2.909e-11,
00172     2.014e-11, 1.363e-11, 8.71e-12, 5.237e-12, 2.718e-12, 1.375e-12,
00173     5.786e-13, 2.16e-13, 7.317e-14, 2.551e-14, 1.055e-14, 4.758e-15,
00174     2.056e-15, 7.703e-16, 2.82e-16, 1.035e-16, 4.382e-17, 1.946e-17,
00175     9.638e-18, 5.2e-18, 2.811e-18, 1.494e-18, 7.925e-19, 4.213e-19,
00176     1.998e-19, 8.78e-20, 3.877e-20, 1.728e-20, 7.743e-21, 3.536e-21,
00177     1.623e-21, 7.508e-22, 3.508e-22, 1.65e-22, 7.837e-23, 3.733e-23,
00178     1.808e-23, 8.77e-24, 4.285e-24, 2.095e-24, 1.032e-24, 5.082e-25,
00179     2.506e-25, 1.236e-25, 6.088e-26, 2.996e-26, 1.465e-26, 0, 0, 0,
00180     0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
00181     0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
00182     0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0
00183   };
00184
00185   static double c2h6[121] = {
00186     2.667e-09, 2.02e-09, 1.658e-09, 1.404e-09, 1.234e-09, 1.109e-09,
00187     1.012e-09, 9.262e-10, 8.472e-10, 7.71e-10, 6.932e-10, 6.216e-10,
00188     5.503e-10, 4.87e-10, 4.342e-10, 3.861e-10, 3.347e-10, 2.772e-10,
00189     2.209e-10, 1.672e-10, 1.197e-10, 8.536e-11, 5.783e-11, 3.846e-11,
00190     2.495e-11, 1.592e-11, 1.017e-11, 6.327e-12, 3.895e-12, 2.403e-12,
00191     1.416e-12, 8.101e-13, 4.649e-13, 2.686e-13, 1.557e-13, 9.14e-14,
00192     5.386e-14, 3.19e-14, 1.903e-14, 1.14e-14, 6.875e-15, 4.154e-15,
00193     2.538e-15, 1.553e-15, 9.548e-16, 5.872e-16, 3.63e-16, 2.244e-16,
00194     1.388e-16, 8.587e-17, 5.308e-17, 3.279e-17, 2.017e-17, 1.238e-17,
00195     7.542e-18, 4.585e-18, 2.776e-18, 1.671e-18, 9.985e-19, 5.937e-19,
00196     3.518e-19, 2.07e-19, 1.215e-19, 7.06e-20, 4.097e-20, 2.37e-20,
00197     1.363e-20, 7.802e-21, 4.441e-21, 2.523e-21, 1.424e-21, 8.015e-22,
00198     4.497e-22, 2.505e-22, 1.391e-22, 7.691e-23, 4.238e-23, 2.331e-23,
00199     1.274e-23, 6.929e-24, 3.752e-24, 2.02e-24, 1.083e-24, 5.774e-25,
00200     3.041e-25, 1.593e-25, 8.308e-26, 4.299e-26, 2.195e-26, 1.112e-26,
00201     0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
00202     0, 0, 0, 0, 0, 0, 0, 0, 0
00203   };
00204
00205   static double ccl4[121] = {
00206     1.075e-10, 1.075e-10, 1.075e-10, 1.075e-10, 1.075e-10, 1.075e-10,
00207     1.075e-10, 1.075e-10, 1.075e-10, 1.06e-10, 1.024e-10, 9.69e-11,
00208     8.93e-11, 8.078e-11, 7.213e-11, 6.307e-11, 5.383e-11, 4.49e-11,
00209     3.609e-11, 2.705e-11, 1.935e-11, 1.385e-11, 8.35e-12, 5.485e-12,
00210     3.853e-12, 2.22e-12, 5.875e-13, 3.445e-13, 1.015e-13, 6.075e-14,
```

```
00211     4.383e-14, 2.692e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14,
00212     1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14,
00213     1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14,
00214     1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14,
00215     1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14,
00216     1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14,
00217     1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14,
00218     1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14,
00219     1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14,
00220     1e-14, 1e-14, 1e-14
00221   };
00222
00223   static double ch4[121] = {
00224     1.864e-06, 1.835e-06, 1.819e-06, 1.805e-06, 1.796e-06, 1.788e-06,
00225     1.782e-06, 1.776e-06, 1.769e-06, 1.761e-06, 1.749e-06, 1.734e-06,
00226     1.716e-06, 1.692e-06, 1.654e-06, 1.61e-06, 1.567e-06, 1.502e-06,
00227     1.433e-06, 1.371e-06, 1.323e-06, 1.277e-06, 1.232e-06, 1.188e-06,
00228     1.147e-06, 1.108e-06, 1.07e-06, 1.027e-06, 9.854e-07, 9.416e-07,
00229     8.933e-07, 8.478e-07, 7.988e-07, 7.515e-07, 7.07e-07, 6.64e-07,
00230     6.239e-07, 5.864e-07, 5.512e-07, 5.184e-07, 4.87e-07, 4.571e-07,
00231     4.296e-07, 4.04e-07, 3.802e-07, 3.578e-07, 3.383e-07, 3.203e-07,
00232     3.032e-07, 2.889e-07, 2.76e-07, 2.635e-07, 2.519e-07, 2.409e-07,
00233     2.302e-07, 2.219e-07, 2.144e-07, 2.071e-07, 1.999e-07, 1.93e-07,
00234     1.862e-07, 1.795e-07, 1.731e-07, 1.668e-07, 1.607e-07, 1.548e-07,
00235     1.49e-07, 1.434e-07, 1.38e-07, 1.328e-07, 1.277e-07, 1.227e-07,
00236     1.18e-07, 1.134e-07, 1.089e-07, 1.046e-07, 1.004e-07, 9.635e-08,
00237     9.245e-08, 8.867e-08, 8.502e-08, 8.15e-08, 7.809e-08, 7.48e-08,
00238     7.159e-08, 6.849e-08, 6.55e-08, 6.262e-08, 5.98e-08, 5.708e-08,
00239     5.448e-08, 5.194e-08, 4.951e-08, 4.72e-08, 4.5e-08, 4.291e-08,
00240     4.093e-08, 3.905e-08, 3.729e-08, 3.563e-08, 3.408e-08, 3.265e-08,
00241     3.128e-08, 2.996e-08, 2.87e-08, 2.76e-08, 2.657e-08, 2.558e-08,
00242     2.467e-08, 2.385e-08, 2.307e-08, 2.234e-08, 2.168e-08, 2.108e-08,
00243     2.05e-08, 1.998e-08, 1.947e-08, 1.902e-08, 1.86e-08, 1.819e-08,
00244     1.782e-08
00245   };
00246
00247   static double clo[121] = {
00248     7.419e-15, 1.061e-14, 1.518e-14, 2.195e-14, 3.175e-14, 4.666e-14,
00249     6.872e-14, 1.03e-13, 1.553e-13, 2.375e-13, 3.664e-13, 5.684e-13,
00250     8.915e-13, 1.402e-12, 2.269e-12, 4.125e-12, 7.501e-12, 1.257e-11,
00251     2.048e-11, 3.338e-11, 5.44e-11, 8.846e-11, 1.008e-10, 1.082e-10,
00252     1.157e-10, 1.232e-10, 1.312e-10, 1.539e-10, 1.822e-10, 2.118e-10,
00253     2.387e-10, 2.687e-10, 2.875e-10, 3.031e-10, 3.23e-10, 3.648e-10,
00254     4.117e-10, 4.477e-10, 4.633e-10, 4.794e-10, 4.95e-10, 5.104e-10,
00255     5.259e-10, 5.062e-10, 4.742e-10, 4.443e-10, 4.051e-10, 3.659e-10,
00256     3.305e-10, 2.911e-10, 2.54e-10, 2.215e-10, 1.927e-10, 1.675e-10,
00257     1.452e-10, 1.259e-10, 1.09e-10, 9.416e-11, 8.119e-11, 6.991e-11,
00258     6.015e-11, 5.163e-11, 4.43e-11, 3.789e-11, 3.24e-11, 2.769e-11,
00259     2.361e-11, 2.011e-11, 1.71e-11, 1.453e-11, 1.233e-11, 1.045e-11,
00260     8.851e-12, 7.48e-12, 6.316e-12, 5.326e-12, 4.487e-12, 3.778e-12,
00261     3.176e-12, 2.665e-12, 2.234e-12, 1.87e-12, 1.563e-12, 1.304e-12,
00262     1.085e-12, 9.007e-13, 7.468e-13, 6.179e-13, 5.092e-13, 4.188e-13,
00263     3.442e-13, 2.816e-13, 2.304e-13, 1.885e-13, 1.542e-13, 1.263e-13,
00264     1.035e-13, 8.5e-14, 7.004e-14, 5.783e-14, 4.795e-14, 4.007e-14,
00265     3.345e-14, 2.792e-14, 2.33e-14, 1.978e-14, 1.686e-14, 1.438e-14,
00266     1.234e-14, 1.07e-14, 9.312e-15, 8.131e-15, 7.164e-15, 6.367e-15,
00267     5.67e-15, 5.088e-15, 4.565e-15, 4.138e-15, 3.769e-15, 3.432e-15,
00268     3.148e-15
00269   };
00270
00271   static double clono2[121] = {
00272     1.011e-13, 1.515e-13, 2.272e-13, 3.446e-13, 5.231e-13, 8.085e-13,
00273     1.253e-12, 1.979e-12, 3.149e-12, 5.092e-12, 8.312e-12, 1.366e-11,
00274     2.272e-11, 3.791e-11, 6.209e-11, 9.101e-11, 1.334e-10, 1.951e-10,
00275     2.853e-10, 3.94e-10, 4.771e-10, 5.771e-10, 6.675e-10, 7.665e-10,
00276     8.504e-10, 8.924e-10, 9.363e-10, 8.923e-10, 8.411e-10, 7.646e-10,
00277     6.525e-10, 5.576e-10, 4.398e-10, 3.403e-10, 2.612e-10, 1.915e-10,
00278     1.407e-10, 1.028e-10, 7.455e-11, 5.42e-11, 3.708e-11, 2.438e-11,
00279     1.618e-11, 1.075e-11, 7.17e-12, 4.784e-12, 3.205e-12, 2.147e-12,
00280     1.44e-12, 9.654e-13, 6.469e-13, 4.332e-13, 2.891e-13, 1.926e-13,
00281     1.274e-13, 8.422e-14, 5.547e-14, 3.636e-14, 2.368e-14, 1.536e-14,
00282     9.937e-15, 6.39e-15, 4.101e-15, 2.61e-15, 1.659e-15, 1.052e-15,
00283     6.638e-16, 4.172e-16, 2.61e-16, 1.63e-16, 1.013e-16, 6.275e-17,
00284     3.879e-17, 2.383e-17, 1.461e-17, 8.918e-18, 5.43e-18, 3.301e-18,
00285     1.997e-18, 1.203e-18, 7.216e-19, 4.311e-19, 2.564e-19, 1.519e-19,
00286     8.911e-20, 5.203e-20, 3.026e-20, 1.748e-20, 9.99e-21, 5.673e-21,
00287     3.215e-21, 1.799e-21, 1.006e-21, 5.628e-22, 3.146e-22, 1.766e-22,
00288     9.94e-23, 5.614e-23, 3.206e-23, 1.841e-23, 1.071e-23, 6.366e-24,
00289     3.776e-24, 2.238e-24, 1.326e-24, 8.253e-25, 5.201e-25, 3.279e-25,
00290     2.108e-25, 1.395e-25, 9.326e-26, 6.299e-26, 4.365e-26, 3.104e-26,
00291     2.219e-26, 1.621e-26, 1.185e-26, 8.92e-27, 6.804e-27, 5.191e-27,
00292     4.041e-27
00293   };
00294
00295   static double co[121] = {
00296     1.907e-07, 1.553e-07, 1.362e-07, 1.216e-07, 1.114e-07, 1.036e-07,
00297     9.737e-08, 9.152e-08, 8.559e-08, 7.966e-08, 7.277e-08, 6.615e-08,
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00298     5.884e-08, 5.22e-08, 4.699e-08, 4.284e-08, 3.776e-08, 3.274e-08,
00299     2.845e-08, 2.479e-08, 2.246e-08, 2.054e-08, 1.991e-08, 1.951e-08,
00300     1.94e-08, 2.009e-08, 2.1e-08, 2.201e-08, 2.322e-08, 2.45e-08,
00301     2.602e-08, 2.73e-08, 2.867e-08, 2.998e-08, 3.135e-08, 3.255e-08,
00302     3.352e-08, 3.426e-08, 3.484e-08, 3.53e-08, 3.593e-08, 3.671e-08,
00303     3.759e-08, 3.945e-08, 4.192e-08, 4.49e-08, 5.03e-08, 5.703e-08,
00304     6.538e-08, 7.878e-08, 9.644e-08, 1.196e-07, 1.498e-07, 1.904e-07,
00305     2.422e-07, 3.055e-07, 3.804e-07, 4.747e-07, 5.899e-07, 7.272e-07,
00306     8.91e-07, 1.071e-06, 1.296e-06, 1.546e-06, 1.823e-06, 2.135e-06,
00307     2.44e-06, 2.714e-06, 2.967e-06, 3.189e-06, 3.391e-06, 3.58e-06,
00308     3.773e-06, 4.022e-06, 4.346e-06, 4.749e-06, 5.199e-06, 5.668e-06,
00309     6.157e-06, 6.688e-06, 7.254e-06, 7.867e-06, 8.539e-06, 9.26e-06,
00310     1.009e-05, 1.119e-05, 1.228e-05, 1.365e-05, 1.506e-05, 1.641e-05,
00311     1.784e-05, 1.952e-05, 2.132e-05, 2.323e-05, 2.531e-05, 2.754e-05,
00312     3.047e-05, 3.459e-05, 3.922e-05, 4.439e-05, 4.825e-05, 5.077e-05,
00313     5.34e-05, 5.618e-05, 5.909e-05, 6.207e-05, 6.519e-05, 6.845e-05,
00314     6.819e-05, 6.726e-05, 6.622e-05, 6.512e-05, 6.671e-05, 6.862e-05,
00315     7.048e-05, 7.264e-05, 7.3e-05, 7.3e-05, 7.3e-05, 7.3e-05, 7.3e-05
00316   };
00317
00318   static double cof2[121] = {
00319     7.5e-14, 1.055e-13, 1.485e-13, 2.111e-13, 3.001e-13, 4.333e-13,
00320     6.269e-13, 9.221e-13, 1.364e-12, 2.046e-12, 3.093e-12, 4.703e-12,
00321     7.225e-12, 1.113e-11, 1.66e-11, 2.088e-11, 2.626e-11, 3.433e-11,
00322     4.549e-11, 5.886e-11, 7.21e-11, 8.824e-11, 1.015e-10, 1.155e-10,
00323     1.288e-10, 1.388e-10, 1.497e-10, 1.554e-10, 1.606e-10, 1.639e-10,
00324     1.64e-10, 1.64e-10, 1.596e-10, 1.542e-10, 1.482e-10, 1.382e-10,
00325     1.289e-10, 1.198e-10, 1.109e-10, 1.026e-10, 9.484e-11, 8.75e-11,
00326     8.086e-11, 7.49e-11, 6.948e-11, 6.446e-11, 5.961e-11, 5.505e-11,
00327     5.085e-11, 4.586e-11, 4.1e-11, 3.665e-11, 3.235e-11, 2.842e-11,
00328     2.491e-11, 2.11e-11, 1.769e-11, 1.479e-11, 1.197e-11, 9.631e-12,
00329     7.74e-12, 6.201e-12, 4.963e-12, 3.956e-12, 3.151e-12, 2.507e-12,
00330     1.99e-12, 1.576e-12, 1.245e-12, 9.83e-13, 7.742e-13, 6.088e-13,
00331     4.782e-13, 3.745e-13, 2.929e-13, 2.286e-13, 1.782e-13, 1.388e-13,
00332     1.079e-13, 8.362e-14, 6.471e-14, 4.996e-14, 3.85e-14, 2.96e-14,
00333     2.265e-14, 1.729e-14, 1.317e-14, 9.998e-15, 7.549e-15, 5.683e-15,
00334     4.273e-15, 3.193e-15, 2.385e-15, 1.782e-15, 1.331e-15, 9.957e-16,
00335     7.461e-16, 5.601e-16, 4.228e-16, 3.201e-16, 2.438e-16, 1.878e-16,
00336     1.445e-16, 1.111e-16, 8.544e-17, 6.734e-17, 5.341e-17, 4.237e-17,
00337     3.394e-17, 2.759e-17, 2.254e-17, 1.851e-17, 1.54e-17, 1.297e-17,
00338     1.096e-17, 9.365e-18, 8e-18, 6.938e-18, 6.056e-18, 5.287e-18,
00339     4.662e-18
00340   };
00341
00342   static double f11[121] = {
00343     2.65e-10, 2.65e-10, 2.65e-10, 2.65e-10, 2.65e-10, 2.65e-10, 2.65e-10,
00344     2.65e-10, 2.65e-10, 2.65e-10, 2.65e-10, 2.65e-10, 2.635e-10, 2.536e-10,
00345     2.44e-10, 2.348e-10, 2.258e-10, 2.153e-10, 2.046e-10, 1.929e-10,
00346     1.782e-10, 1.648e-10, 1.463e-10, 1.291e-10, 1.1e-10, 8.874e-11,
00347     7.165e-11, 5.201e-11, 3.744e-11, 2.577e-11, 1.64e-11, 1.048e-11,
00348     5.993e-12, 3.345e-12, 1.839e-12, 9.264e-13, 4.688e-13, 2.329e-13,
00349     1.129e-13, 5.505e-14, 2.825e-14, 1.492e-14, 7.997e-15, 5.384e-15,
00350     3.988e-15, 2.955e-15, 2.196e-15, 1.632e-15, 1.214e-15, 9.025e-16,
00351     6.708e-16, 4.984e-16, 3.693e-16, 2.733e-16, 2.013e-16, 1.481e-16,
00352     1.087e-16, 7.945e-17, 5.782e-17, 4.195e-17, 3.038e-17, 2.19e-17,
00353     1.577e-17, 1.128e-17, 8.063e-18, 5.753e-18, 4.09e-18, 2.899e-18,
00354     2.048e-18, 1.444e-18, 1.015e-18, 7.12e-19, 4.985e-19, 3.474e-19,
00355     2.417e-19, 1.677e-19, 1.161e-19, 8.029e-20, 5.533e-20, 3.799e-20,
00356     2.602e-20, 1.776e-20, 1.209e-20, 8.202e-21, 5.522e-21, 3.707e-21,
00357     2.48e-21, 1.652e-21, 1.091e-21, 7.174e-22, 4.709e-22, 3.063e-22,
00358     1.991e-22, 1.294e-22, 8.412e-23, 5.483e-23, 3.581e-23, 2.345e-23,
00359     1.548e-23, 1.027e-23, 6.869e-24, 4.673e-24, 3.173e-24, 2.153e-24,
00360     1.461e-24, 1.028e-24, 7.302e-25, 5.188e-25, 3.739e-25, 2.753e-25,
00361     2.043e-25, 1.528e-25, 1.164e-25, 9.041e-26, 7.051e-26, 5.587e-26,
00362     4.428e-26, 3.588e-26, 2.936e-26, 2.402e-26, 1.995e-26
00363   };
00364
00365   static double f12[121] = {
00366     5.45e-10, 5.45e-10, 5.45e-10, 5.45e-10, 5.45e-10, 5.45e-10, 5.45e-10,
00367     5.45e-10, 5.45e-10, 5.45e-10, 5.45e-10, 5.45e-10, 5.429e-10, 5.291e-10,
00368     5.155e-10, 5.022e-10, 4.893e-10, 4.772e-10, 4.655e-10, 4.497e-10,
00369     4.249e-10, 4.015e-10, 3.632e-10, 3.261e-10, 2.858e-10, 2.408e-10,
00370     2.03e-10, 1.685e-10, 1.4e-10, 1.163e-10, 9.65e-11, 8.02e-11, 6.705e-11,
00371     5.624e-11, 4.764e-11, 4.249e-11, 3.792e-11, 3.315e-11, 2.819e-11,
00372     2.4e-11, 1.999e-11, 1.64e-11, 1.352e-11, 1.14e-11, 9.714e-12,
00373     8.28e-12, 7.176e-12, 6.251e-12, 5.446e-12, 4.72e-12, 4.081e-12,
00374     3.528e-12, 3.08e-12, 2.699e-12, 2.359e-12, 2.111e-12, 1.901e-12,
00375     1.709e-12, 1.534e-12, 1.376e-12, 1.233e-12, 1.103e-12, 9.869e-13,
00376     8.808e-13, 7.859e-13, 7.008e-13, 6.241e-13, 5.553e-13, 4.935e-13,
00377     4.383e-13, 3.889e-13, 3.447e-13, 3.054e-13, 2.702e-13, 2.389e-13,
00378     2.11e-13, 1.862e-13, 1.643e-13, 1.448e-13, 1.274e-13, 1.121e-13,
00379     9.844e-14, 8.638e-14, 7.572e-14, 6.62e-14, 5.782e-14, 5.045e-14,
00380     4.394e-14, 3.817e-14, 3.311e-14, 2.87e-14, 2.48e-14, 2.142e-14,
00381     1.851e-14, 1.599e-14, 1.383e-14, 1.196e-14, 1.036e-14, 9e-15,
00382     7.828e-15, 6.829e-15, 5.992e-15, 5.254e-15, 4.606e-15, 4.037e-15,
00383     3.583e-15, 3.19e-15, 2.841e-15, 2.542e-15, 2.291e-15, 2.07e-15,
00384     1.875e-15, 1.71e-15, 1.57e-15, 1.442e-15, 1.333e-15, 1.232e-15,
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00385     1.147e-15, 1.071e-15, 1.001e-15, 9.396e-16
00386   };
00387
00388   static double f14[121] = {
00389     9e-11, 9e-11, 9e-11, 9e-11, 9e-11, 9e-11, 9e-11, 9e-11, 9e-11, 9e-11,
00390     9e-11, 9e-11, 9e-11, 9e-11, 9e-11, 8.91e-11, 8.73e-11, 8.46e-11,
00391     8.19e-11, 7.92e-11, 7.74e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00392     7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00393     7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00394     7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00395     7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00396     7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00397     7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00398     7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00399     7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00400     7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00401     7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00402     7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00403     7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00404     7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00405     7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11
00406   };
00407
00408   static double f22[121] = {
00409     1.4e-10, 1.4e-10, 1.4e-10, 1.4e-10, 1.4e-10, 1.4e-10, 1.4e-10,
00410     1.4e-10, 1.4e-10, 1.4e-10, 1.372e-10, 1.317e-10, 1.235e-10, 1.153e-10,
00411     1.075e-10, 1.002e-10, 9.332e-11, 8.738e-11, 8.194e-11, 7.7e-11,
00412     7.165e-11, 6.753e-11, 6.341e-11, 5.971e-11, 5.6e-11, 5.229e-11,
00413     4.859e-11, 4.488e-11, 4.118e-11, 3.83e-11, 3.568e-11, 3.308e-11,
00414     3.047e-11, 2.82e-11, 2.594e-11, 2.409e-11, 2.237e-11, 2.065e-11,
00415     1.894e-11, 1.771e-11, 1.647e-11, 1.532e-11, 1.416e-11, 1.332e-11,
00416     1.246e-11, 1.161e-11, 1.087e-11, 1.017e-11, 9.471e-12, 8.853e-12,
00417     8.235e-12, 7.741e-12, 7.247e-12, 6.836e-12, 6.506e-12, 6.176e-12,
00418     5.913e-12, 5.65e-12, 5.419e-12, 5.221e-12, 5.024e-12, 4.859e-12,
00419     4.694e-12, 4.546e-12, 4.414e-12, 4.282e-12, 4.15e-12, 4.019e-12,
00420     3.903e-12, 3.805e-12, 3.706e-12, 3.607e-12, 3.508e-12, 3.41e-12,
00421     3.31e-12, 3.212e-12, 3.129e-12, 3.047e-12, 2.964e-12, 2.882e-12,
00422     2.8e-12, 2.734e-12, 2.668e-12, 2.602e-12, 2.537e-12, 2.471e-12,
00423     2.421e-12, 2.372e-12, 2.322e-12, 2.273e-12, 2.224e-12, 2.182e-12,
00424     2.141e-12, 2.1e-12, 2.059e-12, 2.018e-12, 1.977e-12, 1.935e-12,
00425     1.894e-12, 1.853e-12, 1.812e-12, 1.77e-12, 1.73e-12, 1.688e-12,
00426     1.647e-12, 1.606e-12, 1.565e-12, 1.524e-12, 1.483e-12, 1.441e-12,
00427     1.4e-12, 1.359e-12, 1.317e-12, 1.276e-12, 1.235e-12, 1.194e-12,
00428     1.153e-12, 1.112e-12, 1.071e-12, 1.029e-12, 9.883e-13
00429   };
00430
00431   static double h2o[121] = {
00432     0.01166, 0.008269, 0.005742, 0.003845, 0.00277, 0.001897, 0.001272,
00433     0.000827, 0.000539, 0.0003469, 0.0001579, 3.134e-05, 1.341e-05,
00434     6.764e-06, 4.498e-06, 3.703e-06, 3.724e-06, 3.899e-06, 4.002e-06,
00435     4.122e-06, 4.277e-06, 4.438e-06, 4.558e-06, 4.673e-06, 4.763e-06,
00436     4.809e-06, 4.856e-06, 4.936e-06, 5.021e-06, 5.114e-06, 5.222e-06,
00437     5.331e-06, 5.414e-06, 5.488e-06, 5.563e-06, 5.633e-06, 5.704e-06,
00438     5.767e-06, 5.819e-06, 5.872e-06, 5.914e-06, 5.949e-06, 5.984e-06,
00439     6.015e-06, 6.044e-06, 6.073e-06, 6.104e-06, 6.136e-06, 6.167e-06,
00440     6.189e-06, 6.208e-06, 6.226e-06, 6.212e-06, 6.185e-06, 6.158e-06,
00441     6.114e-06, 6.066e-06, 6.018e-06, 5.877e-06, 5.728e-06, 5.582e-06,
00442     5.437e-06, 5.296e-06, 5.156e-06, 5.02e-06, 4.886e-06, 4.754e-06,
00443     4.625e-06, 4.498e-06, 4.374e-06, 4.242e-06, 4.096e-06, 3.955e-06,
00444     3.817e-06, 3.683e-06, 3.491e-06, 3.204e-06, 2.94e-06, 2.696e-06,
00445     2.47e-06, 2.252e-06, 2.019e-06, 1.808e-06, 1.618e-06, 1.445e-06,
00446     1.285e-06, 1.105e-06, 9.489e-07, 8.121e-07, 6.938e-07, 5.924e-07,
00447     5.04e-07, 4.288e-07, 3.648e-07, 3.103e-07, 2.642e-07, 2.252e-07,
00448     1.921e-07, 1.643e-07, 1.408e-07, 1.211e-07, 1.048e-07, 9.063e-08,
00449     7.835e-08, 6.774e-08, 5.936e-08, 5.221e-08, 4.592e-08, 4.061e-08,
00450     3.62e-08, 3.236e-08, 2.902e-08, 2.62e-08, 2.383e-08, 2.171e-08,
00451     1.989e-08, 1.823e-08, 1.684e-08, 1.562e-08, 1.449e-08, 1.351e-08
00452   };
00453
00454   static double h2o2[121] = {
00455     1.779e-10, 7.938e-10, 8.953e-10, 8.032e-10, 6.564e-10, 5.159e-10,
00456     4.003e-10, 3.026e-10, 2.222e-10, 1.58e-10, 1.044e-10, 6.605e-11,
00457     3.413e-11, 1.453e-11, 1.062e-11, 1.009e-11, 9.597e-12, 1.175e-11,
00458     1.572e-11, 2.091e-11, 2.746e-11, 3.603e-11, 4.791e-11, 6.387e-11,
00459     8.239e-11, 1.007e-10, 1.23e-10, 1.363e-10, 1.489e-10, 1.585e-10,
00460     1.608e-10, 1.632e-10, 1.576e-10, 1.502e-10, 1.423e-10, 1.302e-10,
00461     1.192e-10, 1.085e-10, 9.795e-11, 8.854e-11, 8.057e-11, 7.36e-11,
00462     6.736e-11, 6.362e-11, 6.087e-11, 5.825e-11, 5.623e-11, 5.443e-11,
00463     5.27e-11, 5.098e-11, 4.931e-11, 4.769e-11, 4.611e-11, 4.458e-11,
00464     4.308e-11, 4.102e-11, 3.887e-11, 3.682e-11, 3.521e-11, 3.369e-11,
00465     3.224e-11, 3.082e-11, 2.946e-11, 2.814e-11, 2.687e-11, 2.566e-11,
00466     2.449e-11, 2.336e-11, 2.227e-11, 2.123e-11, 2.023e-11, 1.927e-11,
00467     1.835e-11, 1.746e-11, 1.661e-11, 1.58e-11, 1.502e-11, 1.428e-11,
00468     1.357e-11, 1.289e-11, 1.224e-11, 1.161e-11, 1.102e-11, 1.045e-11,
00469     9.895e-12, 9.369e-12, 8.866e-12, 8.386e-12, 7.922e-12, 7.479e-12,
00470     7.06e-12, 6.656e-12, 6.274e-12, 5.914e-12, 5.575e-12, 5.257e-12,
00471     4.959e-12, 4.679e-12, 4.42e-12, 4.178e-12, 3.954e-12, 3.75e-12,
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00472     3.557e-12, 3.372e-12, 3.198e-12, 3.047e-12, 2.908e-12, 2.775e-12,
00473     2.653e-12, 2.544e-12, 2.442e-12, 2.346e-12, 2.26e-12, 2.183e-12,
00474     2.11e-12, 2.044e-12, 1.98e-12, 1.924e-12, 1.871e-12, 1.821e-12,
00475     1.775e-12
00476   };
00477
00478   static double hcn[121] = {
00479     5.5e-10, 5.5e-10, 5.5e-10, 5.5e-10, 5.5e-10, 5.5e-10, 5.5e-10,
00480     5.5e-10, 5.5e-10, 5.5e-10, 5.5e-10, 5.498e-10, 5.495e-10, 5.493e-10,
00481     5.49e-10, 5.488e-10, 4.717e-10, 3.946e-10, 3.174e-10, 2.4e-10,
00482     1.626e-10, 1.619e-10, 1.612e-10, 1.602e-10, 1.593e-10, 1.582e-10,
00483     1.572e-10, 1.56e-10, 1.549e-10, 1.539e-10, 1.53e-10, 1.519e-10,
00484     1.506e-10, 1.487e-10, 1.467e-10, 1.449e-10, 1.43e-10, 1.413e-10,
00485     1.397e-10, 1.382e-10, 1.368e-10, 1.354e-10, 1.337e-10, 1.315e-10,
00486     1.292e-10, 1.267e-10, 1.241e-10, 1.215e-10, 1.19e-10, 1.165e-10,
00487     1.141e-10, 1.118e-10, 1.096e-10, 1.072e-10, 1.047e-10, 1.021e-10,
00488     9.968e-11, 9.739e-11, 9.539e-11, 9.339e-11, 9.135e-11, 8.898e-11,
00489     8.664e-11, 8.439e-11, 8.249e-11, 8.075e-11, 7.904e-11, 7.735e-11,
00490     7.565e-11, 7.399e-11, 7.245e-11, 7.109e-11, 6.982e-11, 6.863e-11,
00491     6.755e-11, 6.657e-11, 6.587e-11, 6.527e-11, 6.476e-11, 6.428e-11,
00492     6.382e-11, 6.343e-11, 6.307e-11, 6.272e-11, 6.238e-11, 6.205e-11,
00493     6.17e-11, 6.137e-11, 6.102e-11, 6.072e-11, 6.046e-11, 6.03e-11,
00494     6.018e-11, 6.01e-11, 6.001e-11, 5.992e-11, 5.984e-11, 5.975e-11,
00495     5.967e-11, 5.958e-11, 5.95e-11, 5.941e-11, 5.933e-11, 5.925e-11,
00496     5.916e-11, 5.908e-11, 5.899e-11, 5.891e-11, 5.883e-11, 5.874e-11,
00497     5.866e-11, 5.858e-11, 5.85e-11, 5.841e-11, 5.833e-11, 5.825e-11,
00498     5.817e-11, 5.808e-11, 5.8e-11, 5.792e-11, 5.784e-11
00499   };
00500
00501   static double hno3[121] = {
00502     1.809e-10, 7.234e-10, 5.899e-10, 4.342e-10, 3.277e-10, 2.661e-10,
00503     2.35e-10, 2.267e-10, 2.389e-10, 2.651e-10, 3.255e-10, 4.099e-10,
00504     5.42e-10, 6.978e-10, 8.807e-10, 1.112e-09, 1.405e-09, 2.04e-09,
00505     3.111e-09, 4.5e-09, 5.762e-09, 7.37e-09, 7.852e-09, 8.109e-09,
00506     8.067e-09, 7.554e-09, 7.076e-09, 6.268e-09, 5.524e-09, 4.749e-09,
00507     3.909e-09, 3.223e-09, 2.517e-09, 1.942e-09, 1.493e-09, 1.122e-09,
00508     8.449e-10, 6.361e-10, 4.787e-10, 3.611e-10, 2.804e-10, 2.215e-10,
00509     1.758e-10, 1.441e-10, 1.197e-10, 9.953e-11, 8.505e-11, 7.334e-11,
00510     6.325e-11, 5.625e-11, 5.058e-11, 4.548e-11, 4.122e-11, 3.748e-11,
00511     3.402e-11, 3.088e-11, 2.8e-11, 2.536e-11, 2.293e-11, 2.072e-11,
00512     1.871e-11, 1.687e-11, 1.52e-11, 1.368e-11, 1.23e-11, 1.105e-11,
00513     9.922e-12, 8.898e-12, 7.972e-12, 7.139e-12, 6.385e-12, 5.708e-12,
00514     5.099e-12, 4.549e-12, 4.056e-12, 3.613e-12, 3.216e-12, 2.862e-12,
00515     2.544e-12, 2.259e-12, 2.004e-12, 1.776e-12, 1.572e-12, 1.391e-12,
00516     1.227e-12, 1.082e-12, 9.528e-13, 8.379e-13, 7.349e-13, 6.436e-13,
00517     5.634e-13, 4.917e-13, 4.291e-13, 3.745e-13, 3.267e-13, 2.854e-13,
00518     2.494e-13, 2.181e-13, 1.913e-13, 1.68e-13, 1.479e-13, 1.31e-13,
00519     1.159e-13, 1.025e-13, 9.067e-14, 8.113e-14, 7.281e-14, 6.535e-14,
00520     5.892e-14, 5.348e-14, 4.867e-14, 4.439e-14, 4.073e-14, 3.76e-14,
00521     3.476e-14, 3.229e-14, 3e-14, 2.807e-14, 2.635e-14, 2.473e-14,
00522     2.332e-14
00523   };
00524
00525   static double hno4[121] = {
00526     6.118e-12, 3.594e-12, 2.807e-12, 3.04e-12, 4.458e-12, 7.986e-12,
00527     1.509e-11, 2.661e-11, 3.738e-11, 4.652e-11, 4.429e-11, 3.992e-11,
00528     3.347e-11, 3.005e-11, 3.173e-11, 4.055e-11, 5.812e-11, 8.489e-11,
00529     1.19e-10, 1.482e-10, 1.766e-10, 2.103e-10, 2.35e-10, 2.598e-10,
00530     2.801e-10, 2.899e-10, 3e-10, 2.817e-10, 2.617e-10, 2.332e-10,
00531     1.933e-10, 1.605e-10, 1.232e-10, 9.285e-11, 6.941e-11, 4.951e-11,
00532     3.539e-11, 2.402e-11, 1.522e-11, 9.676e-12, 6.056e-12, 3.745e-12,
00533     2.34e-12, 1.463e-12, 9.186e-13, 5.769e-13, 3.322e-13, 1.853e-13,
00534     1.035e-13, 7.173e-14, 5.382e-14, 4.036e-14, 3.401e-14, 2.997e-14,
00535     2.635e-14, 2.316e-14, 2.034e-14, 1.783e-14, 1.56e-14, 1.363e-14,
00536     1.19e-14, 1.037e-14, 9.032e-15, 7.846e-15, 6.813e-15, 5.912e-15,
00537     5.121e-15, 4.431e-15, 3.829e-15, 3.306e-15, 2.851e-15, 2.456e-15,
00538     2.114e-15, 1.816e-15, 1.559e-15, 1.337e-15, 1.146e-15, 9.811e-16,
00539     8.389e-16, 7.162e-16, 6.109e-16, 5.203e-16, 4.425e-16, 3.76e-16,
00540     3.184e-16, 2.692e-16, 2.274e-16, 1.917e-16, 1.61e-16, 1.35e-16,
00541     1.131e-16, 9.437e-17, 7.874e-17, 6.57e-17, 5.481e-17, 4.579e-17,
00542     3.828e-17, 3.204e-17, 2.691e-17, 2.264e-17, 1.912e-17, 1.626e-17,
00543     1.382e-17, 1.174e-17, 9.972e-18, 8.603e-18, 7.45e-18, 6.453e-18,
00544     5.623e-18, 4.944e-18, 4.361e-18, 3.859e-18, 3.443e-18, 3.096e-18,
00545     2.788e-18, 2.528e-18, 2.293e-18, 2.099e-18, 1.929e-18, 1.773e-18,
00546     1.64e-18
00547   };
00548
00549   static double hocl[121] = {
00550     1.056e-12, 1.194e-12, 1.35e-12, 1.531e-12, 1.737e-12, 1.982e-12,
00551     2.263e-12, 2.599e-12, 2.991e-12, 3.459e-12, 4.012e-12, 4.662e-12,
00552     5.438e-12, 6.35e-12, 7.425e-12, 8.686e-12, 1.016e-11, 1.188e-11,
00553     1.389e-11, 1.659e-11, 2.087e-11, 2.621e-11, 3.265e-11, 4.064e-11,
00554     4.859e-11, 5.441e-11, 6.09e-11, 6.373e-11, 6.611e-11, 6.94e-11,
00555     7.44e-11, 7.97e-11, 8.775e-11, 9.722e-11, 1.064e-10, 1.089e-10,
00556     1.114e-10, 1.106e-10, 1.053e-10, 1.004e-10, 9.006e-11, 7.778e-11,
00557     6.739e-11, 5.636e-11, 4.655e-11, 3.845e-11, 3.042e-11, 2.368e-11,
00558     1.845e-11, 1.442e-11, 1.127e-11, 8.814e-12, 6.544e-12, 4.763e-12,
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00559     3.449e-12, 2.612e-12, 1.999e-12, 1.526e-12, 1.16e-12, 8.793e-13,
00560     6.655e-13, 5.017e-13, 3.778e-13, 2.829e-13, 2.117e-13, 1.582e-13,
00561     1.178e-13, 8.755e-14, 6.486e-14, 4.799e-14, 3.54e-14, 2.606e-14,
00562     1.916e-14, 1.403e-14, 1.026e-14, 7.48e-15, 5.446e-15, 3.961e-15,
00563     2.872e-15, 2.076e-15, 1.498e-15, 1.077e-15, 7.726e-16, 5.528e-16,
00564     3.929e-16, 2.785e-16, 1.969e-16, 1.386e-16, 9.69e-17, 6.747e-17,
00565     4.692e-17, 3.236e-17, 2.232e-17, 1.539e-17, 1.061e-17, 7.332e-18,
00566     5.076e-18, 3.522e-18, 2.461e-18, 1.726e-18, 1.22e-18, 8.75e-19,
00567     6.264e-19, 4.482e-19, 3.207e-19, 2.368e-19, 1.762e-19, 1.312e-19,
00568     9.891e-20, 7.595e-20, 5.87e-20, 4.567e-20, 3.612e-20, 2.904e-20,
00569     2.343e-20, 1.917e-20, 1.568e-20, 1.308e-20, 1.1e-20, 9.25e-21,
00570     7.881e-21
00571   };
00572
00573   static double n2o[121] = {
00574     3.17e-07, 3.17e-07, 3.17e-07, 3.17e-07, 3.17e-07, 3.17e-07, 3.17e-07,
00575     3.17e-07, 3.17e-07, 3.17e-07, 3.124e-07, 3.077e-07, 3.03e-07,
00576     2.984e-07, 2.938e-07, 2.892e-07, 2.847e-07, 2.779e-07, 2.705e-07,
00577     2.631e-07, 2.557e-07, 2.484e-07, 2.345e-07, 2.201e-07, 2.01e-07,
00578     1.754e-07, 1.532e-07, 1.329e-07, 1.154e-07, 1.003e-07, 8.735e-08,
00579     7.617e-08, 6.512e-08, 5.547e-08, 4.709e-08, 3.915e-08, 3.259e-08,
00580     2.738e-08, 2.327e-08, 1.98e-08, 1.711e-08, 1.493e-08, 1.306e-08,
00581     1.165e-08, 1.049e-08, 9.439e-09, 8.375e-09, 7.391e-09, 6.525e-09,
00582     5.759e-09, 5.083e-09, 4.485e-09, 3.953e-09, 3.601e-09, 3.27e-09,
00583     2.975e-09, 2.757e-09, 2.556e-09, 2.37e-09, 2.195e-09, 2.032e-09,
00584     1.912e-09, 1.79e-09, 1.679e-09, 1.572e-09, 1.482e-09, 1.402e-09,
00585     1.326e-09, 1.254e-09, 1.187e-09, 1.127e-09, 1.071e-09, 1.02e-09,
00586     9.673e-10, 9.193e-10, 8.752e-10, 8.379e-10, 8.017e-10, 7.66e-10,
00587     7.319e-10, 7.004e-10, 6.721e-10, 6.459e-10, 6.199e-10, 5.942e-10,
00588     5.703e-10, 5.488e-10, 5.283e-10, 5.082e-10, 4.877e-10, 4.696e-10,
00589     4.52e-10, 4.355e-10, 4.198e-10, 4.039e-10, 3.888e-10, 3.754e-10,
00590     3.624e-10, 3.499e-10, 3.381e-10, 3.267e-10, 3.163e-10, 3.058e-10,
00591     2.959e-10, 2.864e-10, 2.77e-10, 2.686e-10, 2.604e-10, 2.534e-10,
00592     2.462e-10, 2.386e-10, 2.318e-10, 2.247e-10, 2.189e-10, 2.133e-10,
00593     2.071e-10, 2.014e-10, 1.955e-10, 1.908e-10, 1.86e-10, 1.817e-10
00594   };
00595
00596   static double n2o5[121] = {
00597     1.231e-11, 3.035e-12, 1.702e-12, 9.877e-13, 8.081e-13, 9.039e-13,
00598     1.169e-12, 1.474e-12, 1.651e-12, 1.795e-12, 1.998e-12, 2.543e-12,
00599     4.398e-12, 7.698e-12, 1.28e-11, 2.131e-11, 3.548e-11, 5.894e-11,
00600     7.645e-11, 1.089e-10, 1.391e-10, 1.886e-10, 2.386e-10, 2.986e-10,
00601     3.487e-10, 3.994e-10, 4.5e-10, 4.6e-10, 4.591e-10, 4.1e-10, 3.488e-10,
00602     2.846e-10, 2.287e-10, 1.696e-10, 1.011e-10, 6.428e-11, 4.324e-11,
00603     2.225e-11, 6.214e-12, 3.608e-12, 8.793e-13, 4.491e-13, 1.04e-13,
00604     6.1e-14, 3.436e-14, 6.671e-15, 1.171e-15, 5.848e-16, 1.212e-16,
00605     1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16,
00606     1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16,
00607     1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16,
00608     1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16,
00609     1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16,
00610     1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16,
00611     1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16,
00612     1e-16, 1e-16
00613   };
00614
00615   static double nh3[121] = {
00616     1e-10, 1e-10, 1e-10, 1e-10, 1e-10, 1e-10, 1e-10, 1e-10, 1e-10, 1e-10,
00617     1e-10, 1e-10, 1e-10, 1e-10, 9.444e-11, 8.488e-11, 7.241e-11, 5.785e-11,
00618     4.178e-11, 3.018e-11, 2.18e-11, 1.574e-11, 1.137e-11, 8.211e-12,
00619     5.973e-12, 4.327e-12, 3.118e-12, 2.234e-12, 1.573e-12, 1.04e-12,
00620     6.762e-13, 4.202e-13, 2.406e-13, 1.335e-13, 6.938e-14, 3.105e-14,
00621     1.609e-14, 1.033e-14, 6.432e-15, 4.031e-15, 2.555e-15, 1.656e-15,
00622     1.115e-15, 7.904e-16, 5.63e-16, 4.048e-16, 2.876e-16, 2.004e-16,
00623     1.356e-16, 9.237e-17, 6.235e-17, 4.223e-17, 3.009e-17, 2.328e-17,
00624     2.002e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17,
00625     1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17,
00626     1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17,
00627     1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17,
00628     1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17,
00629     1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17,
00630     1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17,
00631     1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17,
00632     1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17,
00633     1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17,
00634     1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17,
00635     1.914e-17
00636   };
00637
00638   static double no[121] = {
00639     2.586e-10, 4.143e-11, 1.566e-11, 9.591e-12, 8.088e-12, 8.462e-12,
00640     1.013e-11, 1.328e-11, 1.855e-11, 2.678e-11, 3.926e-11, 5.464e-11,
00641     7.012e-11, 8.912e-11, 1.127e-10, 1.347e-10, 1.498e-10, 1.544e-10,
00642     1.602e-10, 1.824e-10, 2.078e-10, 2.366e-10, 2.691e-10, 5.141e-10,
00643     8.259e-10, 1.254e-09, 1.849e-09, 2.473e-09, 3.294e-09, 4.16e-09,
00644     5.095e-09, 6.11e-09, 6.93e-09, 7.888e-09, 8.903e-09, 9.713e-09,
00645     1.052e-08, 1.115e-08, 1.173e-08, 1.21e-08, 1.228e-08, 1.239e-08,
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00646     1.231e-08, 1.213e-08, 1.192e-08, 1.138e-08, 1.085e-08, 1.008e-08,
00647     9.224e-09, 8.389e-09, 7.262e-09, 6.278e-09, 5.335e-09, 4.388e-09,
00648     3.589e-09, 2.761e-09, 2.129e-09, 1.633e-09, 1.243e-09, 9.681e-10,
00649     8.355e-10, 7.665e-10, 7.442e-10, 8.584e-10, 9.732e-10, 1.063e-09,
00650     1.163e-09, 1.286e-09, 1.472e-09, 1.707e-09, 2.032e-09, 2.474e-09,
00651     2.977e-09, 3.506e-09, 4.102e-09, 5.013e-09, 6.493e-09, 8.414e-09,
00652     1.077e-08, 1.367e-08, 1.777e-08, 2.625e-08, 3.926e-08, 5.545e-08,
00653     7.195e-08, 9.464e-08, 1.404e-07, 2.183e-07, 3.329e-07, 4.535e-07,
00654     6.158e-07, 8.187e-07, 1.075e-06, 1.422e-06, 1.979e-06, 2.71e-06,
00655     3.58e-06, 4.573e-06, 5.951e-06, 7.999e-06, 1.072e-05, 1.372e-05,
00656     1.697e-05, 2.112e-05, 2.643e-05, 3.288e-05, 3.994e-05, 4.794e-05,
00657     5.606e-05, 6.383e-05, 7.286e-05, 8.156e-05, 8.883e-05, 9.469e-05,
00658     9.848e-05, 0.0001023, 0.0001066, 0.0001115, 0.0001145, 0.0001142,
00659     0.0001133
00660   };
00661
00662   static double no2[121] = {
00663     3.036e-09, 2.945e-10, 9.982e-11, 5.069e-11, 3.485e-11, 2.982e-11,
00664     2.947e-11, 3.164e-11, 3.714e-11, 4.586e-11, 6.164e-11, 8.041e-11,
00665     9.982e-11, 1.283e-10, 1.73e-10, 2.56e-10, 3.909e-10, 5.959e-10,
00666     9.081e-10, 1.384e-09, 1.788e-09, 2.189e-09, 2.686e-09, 3.091e-09,
00667     3.49e-09, 3.796e-09, 4.2e-09, 5.103e-09, 6.005e-09, 6.3e-09, 6.706e-09,
00668     7.07e-09, 7.434e-09, 7.663e-09, 7.788e-09, 7.8e-09, 7.597e-09,
00669     7.482e-09, 7.227e-09, 6.403e-09, 5.585e-09, 4.606e-09, 3.703e-09,
00670     2.984e-09, 2.183e-09, 1.48e-09, 8.441e-10, 5.994e-10, 3.799e-10,
00671     2.751e-10, 1.927e-10, 1.507e-10, 1.102e-10, 6.971e-11, 5.839e-11,
00672     3.904e-11, 3.087e-11, 2.176e-11, 1.464e-11, 1.209e-11, 8.497e-12,
00673     6.477e-12, 4.371e-12, 2.914e-12, 2.424e-12, 1.753e-12, 1.35e-12,
00674     9.417e-13, 6.622e-13, 5.148e-13, 3.841e-13, 3.446e-13, 3.01e-13,
00675     2.551e-13, 2.151e-13, 1.829e-13, 1.64e-13, 1.475e-13, 1.352e-13,
00676     1.155e-13, 9.963e-14, 9.771e-14, 9.577e-14, 9.384e-14, 9.186e-14,
00677     9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14,
00678     9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14,
00679     9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14,
00680     9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14
00681   };
00682
00683   static double o3[121] = {
00684     2.218e-08, 3.394e-08, 3.869e-08, 4.219e-08, 4.501e-08, 4.778e-08,
00685     5.067e-08, 5.402e-08, 5.872e-08, 6.521e-08, 7.709e-08, 9.461e-08,
00686     1.269e-07, 1.853e-07, 2.723e-07, 3.964e-07, 5.773e-07, 8.2e-07,
00687     1.155e-06, 1.59e-06, 2.076e-06, 2.706e-06, 3.249e-06, 3.848e-06,
00688     4.459e-06, 4.986e-06, 5.573e-06, 5.958e-06, 6.328e-06, 6.661e-06,
00689     6.9e-06, 7.146e-06, 7.276e-06, 7.374e-06, 7.447e-06, 7.383e-06,
00690     7.321e-06, 7.161e-06, 6.879e-06, 6.611e-06, 6.216e-06, 5.765e-06,
00691     5.355e-06, 4.905e-06, 4.471e-06, 4.075e-06, 3.728e-06, 3.413e-06,
00692     3.125e-06, 2.856e-06, 2.607e-06, 2.379e-06, 2.17e-06, 1.978e-06,
00693     1.8e-06, 1.646e-06, 1.506e-06, 1.376e-06, 1.233e-06, 1.102e-06,
00694     9.839e-07, 8.771e-07, 7.814e-07, 6.947e-07, 6.102e-07, 5.228e-07,
00695     4.509e-07, 3.922e-07, 3.501e-07, 3.183e-07, 2.909e-07, 2.686e-07,
00696     2.476e-07, 2.284e-07, 2.109e-07, 2.003e-07, 2.013e-07, 2.022e-07,
00697     2.032e-07, 2.042e-07, 2.097e-07, 2.361e-07, 2.656e-07, 2.989e-07,
00698     3.37e-07, 3.826e-07, 4.489e-07, 5.26e-07, 6.189e-07, 7.312e-07,
00699     8.496e-07, 8.444e-07, 8.392e-07, 8.339e-07, 8.286e-07, 8.234e-07,
00700     8.181e-07, 8.129e-07, 8.077e-07, 8.026e-07, 6.918e-07, 5.176e-07,
00701     3.865e-07, 2.885e-07, 2.156e-07, 1.619e-07, 1.219e-07, 9.161e-08,
00702     6.972e-08, 5.399e-08, 3.498e-08, 2.111e-08, 1.322e-08, 8.482e-09,
00703     5.527e-09, 3.423e-09, 2.071e-09, 1.314e-09, 8.529e-10, 5.503e-10,
00704     3.665e-10
00705   };
00706
00707   static double ocs[121] = {
00708     6e-10, 6e-10, 6e-10, 6e-10, 6e-10, 6e-10, 6e-10, 6e-10, 6e-10, 5.997e-10,
00709     5.989e-10, 5.881e-10, 5.765e-10, 5.433e-10, 5.074e-10, 4.567e-10,
00710     4.067e-10, 3.601e-10, 3.093e-10, 2.619e-10, 2.232e-10, 1.805e-10,
00711     1.46e-10, 1.187e-10, 8.03e-11, 5.435e-11, 3.686e-11, 2.217e-11,
00712     1.341e-11, 8.756e-12, 4.511e-12, 2.37e-12, 1.264e-12, 8.28e-13,
00713     5.263e-13, 3.209e-13, 1.717e-13, 9.068e-14, 4.709e-14, 2.389e-14,
00714     1.236e-14, 1.127e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14,
00715     1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14,
00716     1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14,
00717     1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14,
00718     1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14,
00719     1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14,
00720     1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14,
00721     1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14,
00722     1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14,
00723     1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14,
00724     1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14,
00725     1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14,
00726     1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14,
00727     1.091e-14, 1.091e-14, 1.091e-14
00728   };
00729
00730   static double sf6[121] = {
00731     4.103e-12, 4.103e-12, 4.103e-12, 4.103e-12, 4.103e-12, 4.103e-12,
00732     4.103e-12, 4.103e-12, 4.103e-12, 4.087e-12, 4.064e-12, 4.023e-12,
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00733     3.988e-12, 3.941e-12, 3.884e-12, 3.755e-12, 3.622e-12, 3.484e-12,
00734     3.32e-12, 3.144e-12, 2.978e-12, 2.811e-12, 2.653e-12, 2.489e-12,
00735     2.332e-12, 2.199e-12, 2.089e-12, 2.013e-12, 1.953e-12, 1.898e-12,
00736     1.859e-12, 1.826e-12, 1.798e-12, 1.776e-12, 1.757e-12, 1.742e-12,
00737     1.728e-12, 1.717e-12, 1.707e-12, 1.698e-12, 1.691e-12, 1.685e-12,
00738     1.679e-12, 1.675e-12, 1.671e-12, 1.668e-12, 1.665e-12, 1.663e-12,
00739     1.661e-12, 1.659e-12, 1.658e-12, 1.657e-12, 1.656e-12, 1.655e-12,
00740     1.654e-12, 1.653e-12, 1.653e-12, 1.652e-12, 1.652e-12, 1.652e-12,
00741     1.651e-12, 1.651e-12, 1.651e-12, 1.651e-12, 1.651e-12, 1.651e-12,
00742     1.651e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12,
00743     1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12,
00744     1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12,
00745     1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12,
00746     1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12,
00747     1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12,
00748     1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12,
00749     1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12
00750   };
00751
00752   static double so2[121] = {
00753     1e-10, 1e-10, 1e-10, 1e-10, 1e-10, 1e-10, 1e-10, 1e-10, 1e-10, 1e-10,
00754     1e-10, 1e-10, 9.867e-11, 9.537e-11, 9e-11, 8.404e-11, 7.799e-11,
00755     7.205e-11, 6.616e-11, 6.036e-11, 5.475e-11, 5.007e-11, 4.638e-11,
00756     4.346e-11, 4.055e-11, 3.763e-11, 3.471e-11, 3.186e-11, 2.905e-11,
00757     2.631e-11, 2.358e-11, 2.415e-11, 2.949e-11, 3.952e-11, 5.155e-11,
00758     6.76e-11, 8.741e-11, 1.099e-10, 1.278e-10, 1.414e-10, 1.512e-10,
00759     1.607e-10, 1.699e-10, 1.774e-10, 1.832e-10, 1.871e-10, 1.907e-10,
00760     1.943e-10, 1.974e-10, 1.993e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10,
00761     2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10,
00762     2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10,
00763     2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10,
00764     2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10,
00765     2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10,
00766     2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10,
00767     2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10
00768   };
00769
00770   static int ig_co2 = -999;
00771
00772   double co2, *q[NG] = { NULL };
00773
00774   int ig, ip, iw, iz;
00775
00776   /* Find emitter index of CO2... */
00777   if (ig_co2 == -999)
00778     ig_co2 = find_emitter(ctl, "CO2");
00779
00780   /* Identify variable... */
00781   for (ig = 0; ig < ctl->ng; ig++) {
00782     q[ig] = NULL;
00783     if (strcasecmp(ctl->emitter[ig], "C2H2") == 0)
00784       q[ig] = c2h2;
00785     if (strcasecmp(ctl->emitter[ig], "C2H6") == 0)
00786       q[ig] = c2h6;
00787     if (strcasecmp(ctl->emitter[ig], "CCl4") == 0)
00788       q[ig] = ccl4;
00789     if (strcasecmp(ctl->emitter[ig], "CH4") == 0)
00790       q[ig] = ch4;
00791     if (strcasecmp(ctl->emitter[ig], "ClO") == 0)
00792       q[ig] = clo;
00793     if (strcasecmp(ctl->emitter[ig], "ClONO2") == 0)
00794       q[ig] = clono2;
00795     if (strcasecmp(ctl->emitter[ig], "CO") == 0)
00796       q[ig] = co;
00797     if (strcasecmp(ctl->emitter[ig], "COF2") == 0)
00798       q[ig] = cof2;
00799     if (strcasecmp(ctl->emitter[ig], "F11") == 0)
00800       q[ig] = f11;
00801     if (strcasecmp(ctl->emitter[ig], "F12") == 0)
00802       q[ig] = f12;
00803     if (strcasecmp(ctl->emitter[ig], "F14") == 0)
00804       q[ig] = f14;
00805     if (strcasecmp(ctl->emitter[ig], "F22") == 0)
00806       q[ig] = f22;
00807     if (strcasecmp(ctl->emitter[ig], "H2O") == 0)
00808       q[ig] = h2o;
00809     if (strcasecmp(ctl->emitter[ig], "H2O2") == 0)
00810       q[ig] = h2o2;
00811     if (strcasecmp(ctl->emitter[ig], "HCN") == 0)
00812       q[ig] = hcn;
00813     if (strcasecmp(ctl->emitter[ig], "HNO3") == 0)
00814       q[ig] = hno3;
00815     if (strcasecmp(ctl->emitter[ig], "HNO4") == 0)
00816       q[ig] = hno4;
00817     if (strcasecmp(ctl->emitter[ig], "HOCl") == 0)
00818       q[ig] = hocl;
00819     if (strcasecmp(ctl->emitter[ig], "N2O") == 0)
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00820       q[ig] = n2o;
00821     if (strcasecmp(ctl->emitter[ig], "N2O5") == 0)
00822       q[ig] = n2o5;
00823     if (strcasecmp(ctl->emitter[ig], "NH3") == 0)
00824       q[ig] = nh3;
00825     if (strcasecmp(ctl->emitter[ig], "NO") == 0)
00826       q[ig] = no;
00827     if (strcasecmp(ctl->emitter[ig], "NO2") == 0)
00828       q[ig] = no2;
00829     if (strcasecmp(ctl->emitter[ig], "O3") == 0)
00830       q[ig] = o3;
00831     if (strcasecmp(ctl->emitter[ig], "OCS") == 0)
00832       q[ig] = ocs;
00833     if (strcasecmp(ctl->emitter[ig], "SF6") == 0)
00834       q[ig] = sf6;
00835     if (strcasecmp(ctl->emitter[ig], "SO2") == 0)
00836       q[ig] = so2;
00837   }
00838
00839   /* Loop over atmospheric data points... */
00840   for (ip = 0; ip < atm->np; ip++) {
00841
00842     /* Get altitude index... */
00843     iz = locate_reg(z, 121, atm->z[ip]);
00844
00845     /* Interpolate pressure... */
00846     atm->p[ip] = EXP(z[iz], pre[iz], z[iz + 1], pre[iz + 1], atm->z[ip]);
00847
00848     /* Interpolate temperature... */
00849     atm->t[ip] = LIN(z[iz], tem[iz], z[iz + 1], tem[iz + 1], atm->z[ip]);
00850
00851     /* Interpolate trace gases... */
00852     for (ig = 0; ig < ctl->ng; ig++)
00853       if (q[ig] != NULL)
00854         atm->q[ig][ip] =
00855           LIN(z[iz], q[ig][iz], z[iz + 1], q[ig][iz + 1], atm->z[ip]);
00856       else
00857         atm->q[ig][ip] = 0;
00858
00859     /* Set CO2... */
00860     if (ig_co2 >= 0) {
00861       co2 =
00862         371.789948e-6 + 2.026214e-6 * (atm->time[ip] - 63158400.) / 31557600.;
00863       atm->q[ig_co2][ip] = co2;
00864     }
00865
00866     /* Set extinction to zero... */
00867     for (iw = 0; iw < ctl->nw; iw++)
00868       atm->k[iw][ip] = 0;
00869   }
00870 }
00871
00872 /*****************************************************************************/
00873
00874 double ctmco2(
00875   double nu,
00876   double p,
00877   double t,
00878   double u) {
00879
00880   static double co2296[2001] = { 9.3388e-5, 9.7711e-5, 1.0224e-4, 1.0697e-4,
00881     1.1193e-4, 1.1712e-4, 1.2255e-4, 1.2824e-4, 1.3419e-4, 1.4043e-4,
00882     1.4695e-4, 1.5378e-4, 1.6094e-4, 1.6842e-4, 1.7626e-4, 1.8447e-4,
00883     1.9307e-4, 2.0207e-4, 2.1149e-4, 2.2136e-4, 2.3169e-4, 2.4251e-4,
00884     2.5384e-4, 2.657e-4, 2.7813e-4, 2.9114e-4, 3.0477e-4, 3.1904e-4,
00885     3.3399e-4, 3.4965e-4, 3.6604e-4, 3.8322e-4, 4.0121e-4, 4.2006e-4,
00886     4.398e-4, 4.6047e-4, 4.8214e-4, 5.0483e-4, 5.286e-4, 5.535e-4,
00887     5.7959e-4, 6.0693e-4, 6.3557e-4, 6.6558e-4, 6.9702e-4, 7.2996e-4,
00888     7.6449e-4, 8.0066e-4, 8.3856e-4, 8.7829e-4, 9.1991e-4, 9.6354e-4,
00889     .0010093, .0010572, .0011074, .00116, .0012152, .001273,
00890     .0013336, .0013972, .0014638, .0015336, .0016068, .0016835,
00891     .001764, .0018483, .0019367, .0020295, .0021267, .0022286,
00892     .0023355, .0024476, .0025652, .0026885, .0028178, .0029534,
00893     .0030956, .0032448, .0034012, .0035654, .0037375, .0039181,
00894     .0041076, .0043063, .0045148, .0047336, .0049632, .005204,
00895     .0054567, .0057219, .0060002, .0062923, .0065988, .0069204,
00896     .007258, .0076123, .0079842, .0083746, .0087844, .0092146,
00897     .0096663, .01014, .010638, .011161, .01171, .012286, .012891,
00898     .013527, .014194, .014895, .015631, .016404, .017217, .01807,
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00900     .026649, .027981, .02938, .030851, .032397, .034023, .035732,
00901     .037528, .039416, .041402, .04349, .045685, .047994, .050422,
00902     .052975, .055661, .058486, .061458, .064584, .067873, .071334,
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00904     .10641, .11189, .11767, .12375, .13015, .13689, .14399, .15147,
00905     .15935, .16765, .17639, .18561, .19531, .20554, .21632, .22769,
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00915     12.769, 13.576, 14.437, 15.358, 16.342, 17.39, 18.513, 19.716,
00916     21.003, 22.379, 23.854, 25.436, 27.126, 28.942, 30.89, 32.973,
00917     35.219, 37.634, 40.224, 43.021, 46.037, 49.29, 52.803, 56.447,
00918     60.418, 64.792, 69.526, 74.637, 80.182, 86.193, 92.713, 99.786,
00919     107.47, 115.84, 124.94, 134.86, 145.69, 157.49, 170.3, 184.39,
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00921     386.51, 416.68, 449.89, 490.12, 534.35, 578.25, 632.26, 692.61,
00922     756.43, 834.75, 924.11, 1016.9, 996.96, 1102.7, 1219.2, 1351.9,
00923     1494.3, 1654.1, 1826.5, 2027.9, 2249., 2453.8, 2714.4, 2999.4,
00924     3209.5, 3509., 3840.4, 3907.5, 4190.7, 4533.5, 4648.3, 5059.1,
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00928     1634.2, 1656.3, 1657.9, 1789.5, 1670.8, 1509.5, 8474.6, 7489.2,
00929     6793.6, 6117., 5574.1, 5141.2, 5084.6, 4745.1, 4413.2, 4102.8,
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00935     133.31, 123.48, 114.5, 106.21, 98.591, 91.612, 85.156, 79.204,
00936     73.719, 68.666, 63.975, 59.637, 56.35, 52.545, 49.042, 45.788,
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00938     25.297, 23.731, 22.258, 20.883, 19.603, 18.403, 17.295, 16.249,
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00941     5.9577, 5.6395, 5.3419, 5.063, 4.8037, 4.5608, 4.3452, 4.1364,
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01006     .016304, .017233, .018224, .019281, .020394, .021574, .022836,
01007     .024181, .025594, .027088, .028707, .030401, .032245, .034219,
01008     .036262, .038539, .040987, .043578, .04641, .04949, .052726,
01009     .056326, .0602, .064093, .068521, .073278, .077734, .083064,
01010     .088731, .093885, .1003, .1072, .11365, .12187, .13078, .13989,
01011     .15095, .16299, .17634, .19116, .20628, .22419, .24386, .26587,
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01015     .32607, .3431, .36119, .38029, .41179, .43996, .47144, .51853,
01016     .55362, .59122, .66338, .69877, .74001, .82923, .86907, .90361,
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01022     7.38, 7.5746, 7.9833, 8.3791, 8.3956, 8.7501, 9.1067, 9.072,
01023     9.4649, 9.9112, 10.402, 10.829, 11.605, 12.54, 12.713, 10.443,
01024     10.825, 11.375, 11.955, 12.623, 13.326, 14.101, 15.041, 15.547,
01025     16.461, 17.439, 18.716, 19.84, 21.036, 22.642, 23.901, 25.244,
01026     27.03, 28.411, 29.871, 31.403, 33.147, 34.744, 36.456, 39.239,
01027     43.605, 45.162, 47.004, 49.093, 51.391, 53.946, 56.673, 59.629,
01028     63.167, 66.576, 70.254, 74.222, 78.477, 83.034, 87.914, 93.18,
01029     98.77, 104.74, 111.15, 117.95, 125.23, 133.01, 141.33, 150.21,
01030     159.71, 169.89, 180.93, 192.54, 204.99, 218.34, 232.65, 248.,
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01045     54140., 50840., 50468., 48302., 44915., 40910., 36754., 32755.,
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01051     845.16, 788.22, 735.48, 686.57, 641.21, 599.1, 559.99, 523.64,
01052     489.85, 458.42, 429.16, 401.92, 376.54, 352.88, 330.82, 310.24,
01053     291.03, 273.09, 256.34, 240.69, 226.05, 212.37, 199.57, 187.59,
01054     176.37, 165.87, 156.03, 146.82, 138.17, 130.07, 122.47, 115.34,
01055     108.65, 102.37, 96.473, 90.934, 85.73, 80.84, 76.243, 71.922,
01056     67.858, 64.034, 60.438, 57.052, 53.866, 50.866, 48.04, 45.379,
01057     42.872, 40.51, 38.285, 36.188, 34.211, 32.347, 30.588, 28.929,
01058     27.362, 25.884, 24.489, 23.171, 21.929, 20.755, 19.646, 18.599,
01059     17.61, 16.677, 15.795, 14.961, 14.174, 13.43, 12.725, 12.06,
01060     11.431, 10.834, 10.27, 9.7361, 9.2302, 8.7518, 8.2997, 7.8724,
01061     7.4674, 7.0848, 6.7226, 6.3794, 6.054, 5.745, 5.4525, 5.1752,
01062     4.9121, 4.6625, 4.4259, 4.2015, 3.9888, 3.7872, 3.5961, 3.4149,
01063     3.2431, 3.0802, 2.9257, 2.7792, 2.6402, 2.5084, 2.3834, 2.2648,
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```

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01690     338.26, 299.22, 301.26, 332.38, 382.08, 445.49, 515.87, 590.85,
01691     662.3, 726.05, 955.59, 964.11, 945.17, 891.48, 807.11, 720.9,
01692     803.36, 834.46, 1073.9, 1107.1, 1123.6, 1296., 1393.7, 1303.1,
01693     1284.3, 1161.8, 1078.8, 976.13, 868.72, 767.4, 674.72, 593.73,
01694     523.12, 462.24, 409.75, 364.34, 325., 290.73, 260.76, 234.46,
01695     211.28, 190.78, 172.61, 156.44, 142.01, 129.12, 117.57, 107.2,
01696     97.877, 89.47, 81.882, 75.021, 68.807, 63.171, 58.052, 53.396,
01697     49.155, 45.288, 41.759, 38.531, 35.576, 32.868, 30.384, 28.102,
01698     26.003, 24.071, 22.293, 20.655, 19.147, 17.756, 16.476, 15.292,
01699     14.198, 13.183, 12.241, 11.367, 10.554, 9.7989, 9.0978, 8.4475,
01700     7.845, 7.2868, 6.7704, 6.2927, 5.8508, 5.4421, 5.064, 4.714,
01701     4.3902, 4.0902, 3.8121, 3.5543, 3.315, 3.093, 2.8869, 2.6953,
01702     2.5172, 2.3517, 2.1977, 2.0544, 1.9211, 1.7969, 1.6812, 1.5735,
01703     1.4731, 1.3794, 1.2921, 1.2107, 1.1346, 1.0637, .99744, .93554,
01704     .87771, .82368, .77313, .72587, .6816, .64014, .60134, .565,
01705     .53086, .49883, .46881, .44074, .4144, .38979, .36679, .34513,
01706     .32474, .30552, .28751, .27045, .25458, .23976, .22584, .21278,
01707     .20051, .18899, .17815, .16801, .15846, .14954, .14117, .13328,
01708     .12584
01709   };
01710
01711   double xw, dw, ew, cw296, cw260, cw230, dt230, dt260, dt296, ctw, ctmpth;
01712
01713   int iw;
01714
01715   /* Get CO2 continuum absorption... */
01716   xw = nu / 2 + 1;
01717   if (xw >= 1 && xw < 2001) {
01718     iw = (int) xw;
01719     dw = xw - iw;
01720     ew = 1 - dw;
01721     cw296 = ew * co2296[iw - 1] + dw * co2296[iw];
01722     cw260 = ew * co2260[iw - 1] + dw * co2260[iw];
01723     cw230 = ew * co2230[iw - 1] + dw * co2230[iw];
01724     dt230 = t - 230;
01725     dt260 = t - 260;
01726     dt296 = t - 296;
01727     ctw = dt260 * 5.050505e-4 * dt296 * cw230 - dt230 * 9.259259e-4
01728       * dt296 * cw260 + dt230 * 4.208754e-4 * dt260 * cw296;
01729     ctmpth = u / NA / 1000 * p / P0 * ctw;
01730   } else
01731     ctmpth = 0;
01732   return ctmpth;
01733 }
01734
01735 /*****************************************************************************/
01736
01737 double ctmh2o(
01738   double nu,
01739   double p,
01740   double t,
01741   double q,
01742   double u) {
01743
01744   static double h2o296[2001] = { .17, .1695, .172, .168, .1687, .1624, .1606,
01745     .1508, .1447, .1344, .1214, .1133, .1009, .09217, .08297, .06989,
01746     .06513, .05469, .05056, .04417, .03779, .03484, .02994, .0272,
01747     .02325, .02063, .01818, .01592, .01405, .01251, .0108, .009647,
01748     .008424, .007519, .006555, .00588, .005136, .004511, .003989,
01749     .003509, .003114, .00274, .002446, .002144, .001895, .001676,
01750     .001486, .001312, .001164, .001031, 9.129e-4, 8.106e-4, 7.213e-4,
01751     6.4e-4, 5.687e-4, 5.063e-4, 4.511e-4, 4.029e-4, 3.596e-4,
01752     3.22e-4, 2.889e-4, 2.597e-4, 2.337e-4, 2.108e-4, 1.907e-4,
01753     1.728e-4, 1.57e-4, 1.43e-4, 1.305e-4, 1.195e-4, 1.097e-4,
01754     1.009e-4, 9.307e-5, 8.604e-5, 7.971e-5, 7.407e-5, 6.896e-5,
01755     6.433e-5, 6.013e-5, 5.631e-5, 5.283e-5, 4.963e-5, 4.669e-5,
01756     4.398e-5, 4.148e-5, 3.917e-5, 3.702e-5, 3.502e-5, 3.316e-5,
01757     3.142e-5, 2.978e-5, 2.825e-5, 2.681e-5, 2.546e-5, 2.419e-5,
01758     2.299e-5, 2.186e-5, 2.079e-5, 1.979e-5, 1.884e-5, 1.795e-5,
01759     1.711e-5, 1.633e-5, 1.559e-5, 1.49e-5, 1.426e-5, 1.367e-5,
01760     1.312e-5, 1.263e-5, 1.218e-5, 1.178e-5, 1.143e-5, 1.112e-5,
01761     1.088e-5, 1.07e-5, 1.057e-5, 1.05e-5, 1.051e-5, 1.059e-5,
01762     1.076e-5, 1.1e-5, 1.133e-5, 1.18e-5, 1.237e-5, 1.308e-5,
01763     1.393e-5, 1.483e-5, 1.614e-5, 1.758e-5, 1.93e-5, 2.123e-5,
01764     2.346e-5, 2.647e-5, 2.93e-5, 3.279e-5, 3.745e-5, 4.152e-5,
01765     4.813e-5, 5.477e-5, 6.203e-5, 7.331e-5, 8.056e-5, 9.882e-5,
01766     1.05e-4, 1.21e-4, 1.341e-4, 1.572e-4, 1.698e-4, 1.968e-4,
01767     2.175e-4, 2.431e-4, 2.735e-4, 2.867e-4, 3.19e-4, 3.371e-4,
01768     3.554e-4, 3.726e-4, 3.837e-4, 3.878e-4, 3.864e-4, 3.858e-4,
01769     3.841e-4, 3.852e-4, 3.815e-4, 3.762e-4, 3.618e-4, 3.579e-4,
01770     3.45e-4, 3.202e-4, 3.018e-4, 2.785e-4, 2.602e-4, 2.416e-4,
01771     2.097e-4, 1.939e-4, 1.689e-4, 1.498e-4, 1.308e-4, 1.17e-4,
01772     1.011e-4, 9.237e-5, 7.909e-5, 7.006e-5, 6.112e-5, 5.401e-5,
01773     4.914e-5, 4.266e-5, 3.963e-5, 3.316e-5, 3.037e-5, 2.598e-5,
01774     2.294e-5, 2.066e-5, 1.813e-5, 1.583e-5, 1.423e-5, 1.247e-5,
01775     1.116e-5, 9.76e-6, 8.596e-6, 7.72e-6, 6.825e-6, 6.108e-6,
01776     5.366e-6, 4.733e-6, 4.229e-6, 3.731e-6, 3.346e-6, 2.972e-6,
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01777     2.628e-6, 2.356e-6, 2.102e-6, 1.878e-6, 1.678e-6, 1.507e-6,
01778     1.348e-6, 1.21e-6, 1.089e-6, 9.806e-7, 8.857e-7, 8.004e-7,
01779     7.261e-7, 6.599e-7, 6.005e-7, 5.479e-7, 5.011e-7, 4.595e-7,
01780     4.219e-7, 3.885e-7, 3.583e-7, 3.314e-7, 3.071e-7, 2.852e-7,
01781     2.654e-7, 2.474e-7, 2.311e-7, 2.162e-7, 2.026e-7, 1.902e-7,
01782     1.788e-7, 1.683e-7, 1.587e-7, 1.497e-7, 1.415e-7, 1.338e-7,
01783     1.266e-7, 1.2e-7, 1.138e-7, 1.08e-7, 1.027e-7, 9.764e-8,
01784     9.296e-8, 8.862e-8, 8.458e-8, 8.087e-8, 7.744e-8, 7.429e-8,
01785     7.145e-8, 6.893e-8, 6.664e-8, 6.468e-8, 6.322e-8, 6.162e-8,
01786     6.07e-8, 5.992e-8, 5.913e-8, 5.841e-8, 5.796e-8, 5.757e-8,
01787     5.746e-8, 5.731e-8, 5.679e-8, 5.577e-8, 5.671e-8, 5.656e-8,
01788     5.594e-8, 5.593e-8, 5.602e-8, 5.62e-8, 5.693e-8, 5.725e-8,
01789     5.858e-8, 6.037e-8, 6.249e-8, 6.535e-8, 6.899e-8, 7.356e-8,
01790     7.918e-8, 8.618e-8, 9.385e-8, 1.039e-7, 1.158e-7, 1.29e-7,
01791     1.437e-7, 1.65e-7, 1.871e-7, 2.121e-7, 2.427e-7, 2.773e-7,
01792     3.247e-7, 3.677e-7, 4.037e-7, 4.776e-7, 5.101e-7, 6.214e-7,
01793     6.936e-7, 7.581e-7, 8.486e-7, 9.355e-7, 9.942e-7, 1.063e-6,
01794     1.123e-6, 1.191e-6, 1.215e-6, 1.247e-6, 1.26e-6, 1.271e-6,
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01796     1.344e-6, 1.329e-6, 1.336e-6, 1.327e-6, 1.325e-6, 1.359e-6,
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01807     5.625e-5, 5.045e-5, 4.38e-5, 3.762e-5, 3.29e-5, 2.836e-5,
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01839     5.163e-8, 4.612e-8, 4.119e-8, 3.695e-8, 3.308e-8, 2.976e-8,
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01843     5.733e-9, 5.376e-9, 5.043e-9, 4.75e-9, 4.466e-9, 4.211e-9,
01844     3.977e-9, 3.759e-9, 3.558e-9, 3.373e-9, 3.201e-9, 3.043e-9,
01845     2.895e-9, 2.76e-9, 2.635e-9, 2.518e-9, 2.411e-9, 2.314e-9,
01846     2.23e-9, 2.151e-9, 2.087e-9, 2.035e-9, 1.988e-9, 1.946e-9,
01847     1.927e-9, 1.916e-9, 1.916e-9, 1.933e-9, 1.966e-9, 2.018e-9,
01848     2.09e-9, 2.182e-9, 2.299e-9, 2.442e-9, 2.623e-9, 2.832e-9,
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01857     4.812e-7, 5.018e-7, 4.899e-7, 5.075e-7, 5.073e-7, 5.171e-7,
01858     5.131e-7, 5.25e-7, 5.617e-7, 5.846e-7, 6.239e-7, 6.696e-7,
01859     7.398e-7, 8.073e-7, 9.15e-7, 1.009e-6, 1.116e-6, 1.264e-6,
01860     1.439e-6, 1.644e-6, 1.856e-6, 2.147e-6, 2.317e-6, 2.713e-6,
01861     2.882e-6, 2.99e-6, 3.489e-6, 3.581e-6, 4.033e-6, 4.26e-6,
01862     4.543e-6, 4.84e-6, 4.826e-6, 5.013e-6, 5.252e-6, 5.277e-6,
01863     5.306e-6, 5.236e-6, 5.123e-6, 5.171e-6, 4.843e-6, 4.615e-6,
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01865     2.144e-6, 1.91e-6, 1.639e-6, 1.417e-6, 1.226e-6, 1.065e-6,
01866     9.29e-7, 8.142e-7, 7.161e-7, 6.318e-7, 5.581e-7, 4.943e-7,
01867     4.376e-7, 3.884e-7, 3.449e-7, 3.06e-7, 2.712e-7, 2.412e-7,
01868     2.139e-7, 1.903e-7, 1.689e-7, 1.499e-7, 1.331e-7, 1.183e-7,
01869     1.05e-7, 9.362e-8, 8.306e-8, 7.403e-8, 6.578e-8, 5.853e-8,
01870     5.216e-8, 4.632e-8, 4.127e-8, 3.678e-8, 3.279e-8, 2.923e-8,
01871     2.612e-8, 2.339e-8, 2.094e-8, 1.877e-8, 1.686e-8, 1.516e-8,
01872     1.366e-8, 1.234e-8, 1.114e-8, 1.012e-8, 9.182e-9, 8.362e-9,
01873     7.634e-9, 6.981e-9, 6.406e-9, 5.888e-9, 5.428e-9, 5.021e-9,
01874     4.65e-9, 4.326e-9, 4.033e-9, 3.77e-9, 3.536e-9, 3.327e-9,
01875     3.141e-9, 2.974e-9, 2.825e-9, 2.697e-9, 2.584e-9, 2.488e-9,
01876     2.406e-9, 2.34e-9, 2.292e-9, 2.259e-9, 2.244e-9, 2.243e-9,
01877     2.272e-9, 2.31e-9, 2.378e-9, 2.454e-9, 2.618e-9, 2.672e-9,
01878     2.831e-9, 3.05e-9, 3.225e-9, 3.425e-9, 3.677e-9, 3.968e-9,
01879     4.221e-9, 4.639e-9, 4.96e-9, 5.359e-9, 5.649e-9, 6.23e-9,
01880     6.716e-9, 7.218e-9, 7.746e-9, 7.988e-9, 8.627e-9, 8.999e-9,
01881     9.442e-9, 9.82e-9, 1.015e-8, 1.06e-8, 1.079e-8, 1.109e-8,
01882     1.137e-8, 1.186e-8, 1.18e-8, 1.187e-8, 1.194e-8, 1.192e-8,
01883     1.224e-8, 1.245e-8, 1.246e-8, 1.318e-8, 1.377e-8, 1.471e-8,
01884     1.582e-8, 1.713e-8, 1.853e-8, 2.063e-8, 2.27e-8, 2.567e-8,
01885     2.891e-8, 3.264e-8, 3.744e-8, 4.286e-8, 4.915e-8, 5.623e-8,
01886     6.336e-8, 7.293e-8, 8.309e-8, 9.319e-8, 1.091e-7, 1.243e-7,
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02739     4.458e-12, 5.048e-12, 5.511e-12, 5.898e-12, 6.204e-12, 6.293e-12,
02740     6.386e-12, 6.467e-12, 6.507e-12, 6.466e-12, 6.443e-12, 6.598e-12,
02741     6.873e-12, 7.3e-12, 7.816e-12, 8.368e-12, 8.643e-12, 8.466e-12,
02742     7.871e-12, 6.853e-12, 5.714e-12, 4.482e-12, 3.392e-12, 2.613e-12,
02743     2.008e-12, 1.562e-12, 1.228e-12, 9.888e-13, 7.646e-13, 5.769e-13,
02744     4.368e-13, 3.324e-13, 2.508e-13, 1.916e-13
02745   };
02746
02747   static double xfcrev[15] =
02748     { 1.003, 1.009, 1.015, 1.023, 1.029, 1.033, 1.037,
02749     1.039, 1.04, 1.046, 1.036, 1.027, 1.01, 1.002, 1.
02750   };
02751
02752   double a1, a2, a3, dw, ew, dx, xw, xx, vf2, vf6, cw260, cw296,
02753     sfac, fscal, cwfrn, ctmpth, ctwfrn, ctwslf;
02754
02755   int iw, ix;
02756
02757   /* Get H2O continuum absorption... */
02758   xw = nu / 10 + 1;
02759   if (xw >= 1 && xw < 2001) {
02760     iw = (int) xw;
02761     dw = xw - iw;
02762     ew = 1 - dw;
02763     cw296 = ew * h2o296[iw - 1] + dw * h2o296[iw];
02764     cw260 = ew * h2o260[iw - 1] + dw * h2o260[iw];
02765     cwfrn = ew * h2ofrn[iw - 1] + dw * h2ofrn[iw];
02766     if (nu <= 820 || nu >= 960) {
02767       sfac = 1;
02768     } else {
02769       xx = (nu - 820) / 10;
02770       ix = (int) xx;
02771       dx = xx - ix;
02772       sfac = (1 - dx) * xfcrev[ix] + dx * xfcrev[ix + 1];
02773     }
02774     ctwslf = sfac * cw296 * pow(cw260 / cw296, (296 - t) / (296 - 260));
02775     vf2 = POW2(nu - 370);
02776     vf6 = POW3(vf2);
02777     fscal = 36100 / (vf2 + vf6 * 1e-8 + 36100) * -.25 + 1;
02778     ctwfrn = cwfrn * fscal;
02779     a1 = nu * u * tanh(.7193876 / t * nu);
02780     a2 = 296 / t;
02781     a3 = p / P0 * (q * ctwslf + (1 - q) * ctwfrn) * 1e-20;
02782     ctmpth = a1 * a2 * a3;
02783   } else
02784     ctmpth = 0;
02785   return ctmpth;
02786 }
02787
02788 /*****************************************************************************/
02789
02790 double ctmn2(
02791   double nu,
02792   double p,
02793   double t) {
02794
02795   static double ba[98] = { 0., 4.45e-8, 5.22e-8, 6.46e-8, 7.75e-8, 9.03e-8,
02796     1.06e-7, 1.21e-7, 1.37e-7, 1.57e-7, 1.75e-7, 2.01e-7, 2.3e-7,
02797     2.59e-7, 2.95e-7, 3.26e-7, 3.66e-7, 4.05e-7, 4.47e-7, 4.92e-7,
02798     5.34e-7, 5.84e-7, 6.24e-7, 6.67e-7, 7.14e-7, 7.26e-7, 7.54e-7,
02799     7.84e-7, 8.09e-7, 8.42e-7, 8.62e-7, 8.87e-7, 9.11e-7, 9.36e-7,
02800     9.76e-7, 1.03e-6, 1.11e-6, 1.23e-6, 1.39e-6, 1.61e-6, 1.76e-6,
02801     1.94e-6, 1.97e-6, 1.87e-6, 1.75e-6, 1.56e-6, 1.42e-6, 1.35e-6,
02802     1.32e-6, 1.29e-6, 1.29e-6, 1.29e-6, 1.3e-6, 1.32e-6, 1.33e-6,
02803     1.34e-6, 1.35e-6, 1.33e-6, 1.31e-6, 1.29e-6, 1.24e-6, 1.2e-6,
02804     1.16e-6, 1.1e-6, 1.04e-6, 9.96e-7, 9.38e-7, 8.63e-7, 7.98e-7,
02805     7.26e-7, 6.55e-7, 5.94e-7, 5.35e-7, 4.74e-7, 4.24e-7, 3.77e-7,
02806     3.33e-7, 2.96e-7, 2.63e-7, 2.34e-7, 2.08e-7, 1.85e-7, 1.67e-7,
02807     1.47e-7, 1.32e-7, 1.2e-7, 1.09e-7, 9.85e-8, 9.08e-8, 8.18e-8,
02808     7.56e-8, 6.85e-8, 6.14e-8, 5.83e-8, 5.77e-8, 5e-8, 4.32e-8, 0.
02809   };
02810
02811   static double betaa[98] = { 802., 802., 761., 722., 679., 646., 609., 562.,
02812     511., 472., 436., 406., 377., 355., 338., 319., 299., 278., 255.,
02813     233., 208., 184., 149., 107., 66., 25., -13., -49., -82., -104.,
02814     -119., -130., -139., -144., -146., -146., -147., -148., -150.,
02815     -153., -160., -169., -181., -189., -195., -200., -205., -209.,
02816     -211., -210., -210., -209., -205., -199., -190., -180., -168.,
02817     -157., -143., -126., -108., -89., -63., -32., 1., 35., 65., 95.,
02818     121., 141., 152., 161., 164., 164., 161., 155., 148., 143., 137.,
02819     133., 131., 133., 139., 150., 165., 187., 213., 248., 284., 321.,
02820     372., 449., 514., 569., 609., 642., 673., 673.
```

```
02821   };
02822
02823   static double nua[98] = { 2120., 2125., 2130., 2135., 2140., 2145., 2150.,
02824     2155., 2160., 2165., 2170., 2175., 2180., 2185., 2190., 2195.,
02825     2200., 2205., 2210., 2215., 2220., 2225., 2230., 2235., 2240.,
02826     2245., 2250., 2255., 2260., 2265., 2270., 2275., 2280., 2285.,
02827     2290., 2295., 2300., 2305., 2310., 2315., 2320., 2325., 2330.,
02828     2335., 2340., 2345., 2350., 2355., 2360., 2365., 2370., 2375.,
02829     2380., 2385., 2390., 2395., 2400., 2405., 2410., 2415., 2420.,
02830     2425., 2430., 2435., 2440., 2445., 2450., 2455., 2460., 2465.,
02831     2470., 2475., 2480., 2485., 2490., 2495., 2500., 2505., 2510.,
02832     2515., 2520., 2525., 2530., 2535., 2540., 2545., 2550., 2555.,
02833     2560., 2565., 2570., 2575., 2580., 2585., 2590., 2595., 2600., 2605.
02834   };
02835
02836   double b, beta, q_n2 = 0.79, t0 = 273, tr = 296;
02837
02838   int idx;
02839
02840   /* Check wavenumber range... */
02841   if (nu < nua[0] || nu > nua[97])
02842     return 0;
02843
02844   /* Interpolate B and beta... */
02845   idx = locate_reg(nua, 98, nu);
02846   b = LIN(nua[idx], ba[idx], nua[idx + 1], ba[idx + 1], nu);
02847   beta = LIN(nua[idx], betaa[idx], nua[idx + 1], betaa[idx + 1], nu);
02848
02849   /* Compute absorption coefficient... */
02850   return 0.1 * POW2(p / P0 * t0 / t) * exp(beta * (1 / tr - 1 / t))
02851     * q_n2 * b * (q_n2 + (1 - q_n2) * (1.294 - 0.4545 * t / tr));
02852 }
02853
02854 /*****************************************************************************/
02855
02856 double ctmo2(
02857   double nu,
02858   double p,
02859   double t) {
02860
02861   static double ba[90] = { 0., .061, .074, .084, .096, .12, .162, .208, .246,
02862     .285, .314, .38, .444, .5, .571, .673, .768, .853, .966, 1.097,
02863     1.214, 1.333, 1.466, 1.591, 1.693, 1.796, 1.922, 2.037, 2.154,
02864     2.264, 2.375, 2.508, 2.671, 2.847, 3.066, 3.417, 3.828, 4.204,
02865     4.453, 4.599, 4.528, 4.284, 3.955, 3.678, 3.477, 3.346, 3.29,
02866     3.251, 3.231, 3.226, 3.212, 3.192, 3.108, 3.033, 2.911, 2.798,
02867     2.646, 2.508, 2.322, 2.13, 1.928, 1.757, 1.588, 1.417, 1.253,
02868     1.109, .99, .888, .791, .678, .587, .524, .464, .403, .357, .32,
02869     .29, .267, .242, .215, .182, .16, .146, .128, .103, .087, .081,
02870     .071, .064, 0.
02871   };
02872
02873   static double betaa[90] = { 467., 467., 400., 315., 379., 368., 475., 521.,
02874     531., 512., 442., 444., 430., 381., 335., 324., 296., 248., 215.,
02875     193., 158., 127., 101., 71., 31., -6., -26., -47., -63., -79.,
02876     -88., -88., -87., -90., -98., -99., -109., -134., -160., -167.,
02877     -164., -158., -153., -151., -156., -166., -168., -173., -170.,
02878     -161., -145., -126., -108., -84., -59., -29., 4., 41., 73., 97.,
02879     123., 159., 198., 220., 242., 256., 281., 311., 334., 319., 313.,
02880     321., 323., 310., 315., 320., 335., 361., 378., 373., 338., 319.,
02881     346., 322., 291., 290., 350., 371., 504., 504.
02882   };
02883
02884   static double nua[90] = { 1360., 1365., 1370., 1375., 1380., 1385., 1390.,
02885     1395., 1400., 1405., 1410., 1415., 1420., 1425., 1430., 1435.,
02886     1440., 1445., 1450., 1455., 1460., 1465., 1470., 1475., 1480.,
02887     1485., 1490., 1495., 1500., 1505., 1510., 1515., 1520., 1525.,
02888     1530., 1535., 1540., 1545., 1550., 1555., 1560., 1565., 1570.,
02889     1575., 1580., 1585., 1590., 1595., 1600., 1605., 1610., 1615.,
02890     1620., 1625., 1630., 1635., 1640., 1645., 1650., 1655., 1660.,
02891     1665., 1670., 1675., 1680., 1685., 1690., 1695., 1700., 1705.,
02892     1710., 1715., 1720., 1725., 1730., 1735., 1740., 1745., 1750.,
02893     1755., 1760., 1765., 1770., 1775., 1780., 1785., 1790., 1795.,
02894     1800., 1805.
02895   };
02896
02897   double b, beta, q_o2 = 0.21, t0 = 273, tr = 296;
02898
02899   int idx;
02900
02901   /* Check wavenumber range... */
02902   if (nu < nua[0] || nu > nua[89])
02903     return 0;
02904
02905   /* Interpolate B and beta... */
02906   idx = locate_reg(nua, 90, nu);
02907   b = LIN(nua[idx], ba[idx], nua[idx + 1], ba[idx + 1], nu);
```

```
02908   beta = LIN(nua[idx], betaa[idx], nua[idx + 1], betaa[idx + 1], nu);
02909
02910   /* Compute absorption coefficient... */
02911   return 0.1 * POW2(p / P0 * t0 / t) * exp(beta * (1 / tr - 1 / t)) * q_o2 *
02912     b;
02913 }
02914
02915 /*****************************************************************************/
02916
02917 void copy_atm(
02918   ctl_t * ctl,
02919   atm_t * atm_dest,
02920   atm_t * atm_src,
02921   int init) {
02922
02923   int ig, ip, iw;
02924
02925   size_t s;
02926
02927   /* Data size... */
02928   s = (size_t) atm_src->np * sizeof(double);
02929
02930   /* Copy data... */
02931   atm_dest->np = atm_src->np;
02932   memcpy(atm_dest->time, atm_src->time, s);
02933   memcpy(atm_dest->z, atm_src->z, s);
02934   memcpy(atm_dest->lon, atm_src->lon, s);
02935   memcpy(atm_dest->lat, atm_src->lat, s);
02936   memcpy(atm_dest->p, atm_src->p, s);
02937   memcpy(atm_dest->t, atm_src->t, s);
02938   for (ig = 0; ig < ctl->ng; ig++)
02939     memcpy(atm_dest->q[ig], atm_src->q[ig], s);
02940   for (iw = 0; iw < ctl->nw; iw++)
02941     memcpy(atm_dest->k[iw], atm_src->k[iw], s);
02942
02943   /* Initialize... */
02944   if (init)
02945     for (ip = 0; ip < atm_dest->np; ip++) {
02946       atm_dest->p[ip] = 0;
02947       atm_dest->t[ip] = 0;
02948       for (ig = 0; ig < ctl->ng; ig++)
02949         atm_dest->q[ig][ip] = 0;
02950       for (iw = 0; iw < ctl->nw; iw++)
02951         atm_dest->k[iw][ip] = 0;
02952     }
02953 }
02954
02955 /*****************************************************************************/
02956
02957 void copy_obs(
02958   ctl_t * ctl,
02959   obs_t * obs_dest,
02960   obs_t * obs_src,
02961   int init) {
02962
02963   int id, ir;
02964
02965   size_t s;
02966
02967   /* Data size... */
02968   s = (size_t) obs_src->nr * sizeof(double);
02969
02970   /* Copy data... */
02971   obs_dest->nr = obs_src->nr;
02972   memcpy(obs_dest->time, obs_src->time, s);
02973   memcpy(obs_dest->obsz, obs_src->obsz, s);
02974   memcpy(obs_dest->obslon, obs_src->obslon, s);
02975   memcpy(obs_dest->obslat, obs_src->obslat, s);
02976   memcpy(obs_dest->vpz, obs_src->vpz, s);
02977   memcpy(obs_dest->vplon, obs_src->vplon, s);
02978   memcpy(obs_dest->vplat, obs_src->vplat, s);
02979   memcpy(obs_dest->tpz, obs_src->tpz, s);
02980   memcpy(obs_dest->tplon, obs_src->tplon, s);
02981   memcpy(obs_dest->tplat, obs_src->tplat, s);
02982   for (id = 0; id < ctl->nd; id++)
02983     memcpy(obs_dest->rad[id], obs_src->rad[id], s);
02984   for (id = 0; id < ctl->nd; id++)
02985     memcpy(obs_dest->tau[id], obs_src->tau[id], s);
02986
02987   /* Initialize... */
02988   if (init)
02989     for (id = 0; id < ctl->nd; id++)
02990       for (ir = 0; ir < obs_dest->nr; ir++)
02991         if (gsl_finite(obs_dest->rad[id][ir])) {
02992           obs_dest->rad[id][ir] = 0;
02993           obs_dest->tau[id][ir] = 0;
02994         }
```

```
02995 }
02996
02997 /*****************************************************************************/
02998
02999 int find_emitter(
03000   ctl_t * ctl,
03001   const char *emitter) {
03002
03003   int ig;
03004
03005   for (ig = 0; ig < ctl->ng; ig++)
03006     if (strcasecmp(ctl->emitter[ig], emitter) == 0)
03007       return ig;
03008
03009   return -1;
03010 }
03011
03012 /*****************************************************************************/
03013
03014 void formod(
03015   ctl_t * ctl,
03016   atm_t * atm,
03017   obs_t * obs) {
03018
03019   int id, ir, *mask;
03020
03021   /* Allocate... */
03022   ALLOC(mask, int,
03023         ND * NR);
03024
03025   /* Save observation mask... */
03026   for (id = 0; id < ctl->nd; id++)
03027     for (ir = 0; ir < obs->nr; ir++)
03028       mask[id * NR + ir] = !gsl_finite(obs->rad[id][ir]);
03029
03030   /* Hydrostatic equilibrium... */
03031   hydrostatic(ctl, atm);
03032
03033   /* Calculate pencil beams... */
03034   for (ir = 0; ir < obs->nr; ir++)
03035     formod_pencil(ctl, atm, obs, ir);
03036
03037   /* Apply field-of-view convolution... */
03038   formod_fov(ctl, obs);
03039
03040   /* Convert radiance to brightness temperature... */
03041   if (ctl->write_bbt)
03042     for (id = 0; id < ctl->nd; id++)
03043       for (ir = 0; ir < obs->nr; ir++)
03044         obs->rad[id][ir] = brightness(obs->rad[id][ir], ctl->nu[id]);
03045
03046   /* Apply observation mask... */
03047   for (id = 0; id < ctl->nd; id++)
03048     for (ir = 0; ir < obs->nr; ir++)
03049       if (mask[id * NR + ir])
03050         obs->rad[id][ir] = GSL_NAN;
03051
03052   /* Free... */
03053   free(mask);
03054 }
03055
03056 /*****************************************************************************/
03057
03058 void formod_continua(
03059   ctl_t * ctl,
03060   los_t * los,
03061   int ip,
03062   double *beta) {
03063
03064   static int ig_co2 = -999, ig_h2o = -999;
03065
03066   int id;
03067
03068   /* Extinction... */
03069   for (id = 0; id < ctl->nd; id++)
03070     beta[id] = los->k[ctl->window[id]][ip];
03071
03072   /* CO2 continuum... */
03073   if (ctl->ctm_co2) {
03074     if (ig_co2 == -999)
03075       ig_co2 = find_emitter(ctl, "CO2");
03076     if (ig_co2 >= 0)
03077       for (id = 0; id < ctl->nd; id++)
03078         beta[id] += ctmco2(ctl->nu[id], los->p[ip], los->t[ip],
03079                            los->u[ig_co2][ip]) / los->ds[ip];
03080   }
03081
```

```
03082   /* H2O continuum... */
03083   if (ctl->ctm_h2o) {
03084     if (ig_h2o == -999)
03085       ig_h2o = find_emitter(ctl, "H2O");
03086     if (ig_h2o >= 0)
03087       for (id = 0; id < ctl->nd; id++)
03088         beta[id] += ctmh2o(ctl->nu[id], los->p[ip], los->t[ip],
03089                            los->q[ig_h2o][ip],
03090                            los->u[ig_h2o][ip]) / los->ds[ip];
03091   }
03092
03093   /* N2 continuum... */
03094   if (ctl->ctm_n2)
03095     for (id = 0; id < ctl->nd; id++)
03096       beta[id] += ctmn2(ctl->nu[id], los->p[ip], los->t[ip]);
03097
03098   /* O2 continuum... */
03099   if (ctl->ctm_o2)
03100     for (id = 0; id < ctl->nd; id++)
03101       beta[id] += ctmo2(ctl->nu[id], los->p[ip], los->t[ip]);
03102 }
03103
03104 /*****************************************************************************/
03105
03106 void formod_fov(
03107   ctl_t * ctl,
03108   obs_t * obs) {
03109
03110   static double dz[NSHAPE], w[NSHAPE];
03111
03112   static int init = 0, n;
03113
03114   obs_t *obs2;
03115
03116   double rad[ND][NR], tau[ND][NR], wsum, z[NR], zfov;
03117
03118   int i, id, idx, ir, ir2, nz;
03119
03120   /* Do not take into account FOV... */
03121   if (ctl->fov[0] == '-')
03122     return;
03123
03124   /* Initialize FOV data... */
03125   if (!init) {
03126     init = 1;
03127     read_shape(ctl->fov, dz, w, &n);
03128   }
03129
03130   /* Allocate... */
03131   ALLOC(obs2, obs_t, 1);
03132
03133   /* Copy observation data... */
03134   copy_obs(ctl, obs2, obs, 0);
03135
03136   /* Loop over ray paths... */
03137   for (ir = 0; ir < obs->nr; ir++) {
03138
03139     /* Get radiance and transmittance profiles... */
03140     nz = 0;
03141     for (ir2 = GSL_MAX(ir - NFOV, 0); ir2 < GSL_MIN(ir + 1 + NFOV, obs->nr);
03142          ir2++)
03143       if (obs->time[ir2] == obs->time[ir]) {
03144         z[nz] = obs2->vpz[ir2];
03145         for (id = 0; id < ctl->nd; id++) {
03146           rad[id][nz] = obs2->rad[id][ir2];
03147           tau[id][nz] = obs2->tau[id][ir2];
03148         }
03149         nz++;
03150       }
03151     if (nz < 2)
03152       ERRMSG("Cannot apply FOV convolution!");
03153
03154     /* Convolute profiles with FOV... */
03155     wsum = 0;
03156     for (id = 0; id < ctl->nd; id++) {
03157       obs->rad[id][ir] = 0;
03158       obs->tau[id][ir] = 0;
03159     }
03160     for (i = 0; i < n; i++) {
03161       zfov = obs->vpz[ir] + dz[i];
03162       idx = locate_irr(z, nz, zfov);
03163       for (id = 0; id < ctl->nd; id++) {
03164         obs->rad[id][ir] += w[i]
03165           * LIN(z[idx], rad[id][idx], z[idx + 1], rad[id][idx + 1], zfov);
03166         obs->tau[id][ir] += w[i]
03167           * LIN(z[idx], tau[id][idx], z[idx + 1], tau[id][idx + 1], zfov);
03168       }
```

```
03169       wsum += w[i];
03170     }
03171     for (id = 0; id < ctl->nd; id++) {
03172       obs->rad[id][ir] /= wsum;
03173       obs->tau[id][ir] /= wsum;
03174     }
03175   }
03176
03177   /* Free... */
03178   free(obs2);
03179 }
03180
03181 /*****************************************************************************/
03182
03183 void formod_pencil(
03184   ctl_t * ctl,
03185   atm_t * atm,
03186   obs_t * obs,
03187   int ir) {
03188
03189   static tbl_t *tbl;
03190
03191   static int init = 0;
03192
03193   los_t *los;
03194
03195   double beta_ctm[ND], eps, src_planck[ND], tau_path[NG][ND], tau_gas[ND];
03196
03197   int id, ip;
03198
03199   /* Initialize look-up tables... */
03200   if (!init) {
03201     init = 1;
03202     ALLOC(tbl, tbl_t, 1);
03203     init_tbl(ctl, tbl);
03204   }
03205
03206   /* Allocate... */
03207   ALLOC(los, los_t, 1);
03208
03209   /* Initialize... */
03210   for (id = 0; id < ctl->nd; id++) {
03211     obs->rad[id][ir] = 0;
03212     obs->tau[id][ir] = 1;
03213   }
03214
03215   /* Raytracing... */
03216   raytrace(ctl, atm, obs, los, ir);
03217
03218   /* Loop over LOS points... */
03219   for (ip = 0; ip < los->np; ip++) {
03220
03221     /* Get trace gas transmittance... */
03222     intpol_tbl(ctl, tbl, los, ip, tau_path, tau_gas);
03223
03224     /* Get continuum absorption... */
03225     formod_continua(ctl, los, ip, beta_ctm);
03226
03227     /* Compute Planck function... */
03228     formod_srcfunc(ctl, tbl, los->t[ip], src_planck);
03229
03230     /* Loop over channels... */
03231     for (id = 0; id < ctl->nd; id++)
03232       if (tau_gas[id] > 0) {
03233
03234         /* Get segment emissivity... */
03235         eps = 1 - tau_gas[id] * exp(-beta_ctm[id] * los->ds[ip]);
03236
03237         /* Compute radiance... */
03238         obs->rad[id][ir] += src_planck[id] * eps * obs->tau[id][ir];
03239
03240         /* Compute path transmittance... */
03241         obs->tau[id][ir] *= (1 - eps);
03242       }
03243   }
03244
03245   /* Add surface... */
03246   if (los->tsurf > 0) {
03247     formod_srcfunc(ctl, tbl, los->tsurf, src_planck);
03248     for (id = 0; id < ctl->nd; id++)
03249       obs->rad[id][ir] += src_planck[id] * obs->tau[id][ir];
03250   }
03251
03252   /* Free... */
03253   free(los);
03254 }
03255
```

```
03256 /*****************************************************************************/
03257
03258 void formod_srcfunc(
03259   ctl_t * ctl,
03260   tbl_t * tbl,
03261   double t,
03262   double *src) {
03263
03264   int id, it;
03265
03266   /* Determine index in temperature array... */
03267   it = locate_reg(tbl->st, TBLNS, t);
03268
03269   /* Interpolate Planck function value... */
03270   for (id = 0; id < ctl->nd; id++)
03271     src[id] = LIN(tbl->st[it], tbl->sr[id][it],
03272                   tbl->st[it + 1], tbl->sr[id][it + 1], t);
03273 }
03274
03275 /*****************************************************************************/
03276
03277 void geo2cart(
03278   double z,
03279   double lon,
03280   double lat,
03281   double *x) {
03282
03283   double radius;
03284
03285   radius = z + RE;
03286   x[0] = radius * cos(lat / 180 * M_PI) * cos(lon / 180 * M_PI);
03287   x[1] = radius * cos(lat / 180 * M_PI) * sin(lon / 180 * M_PI);
03288   x[2] = radius * sin(lat / 180 * M_PI);
03289 }
03290
03291 /*****************************************************************************/
03292
03293 void hydrostatic(
03294   ctl_t * ctl,
03295   atm_t * atm) {
03296
03297   static int ig_h2o = -999;
03298
03299   double dzmin = 1e99, e = 0, mean, mmair = 28.96456e-3, mmh2o = 18.0153e-3;
03300
03301   int i, ip, ipref = 0, ipts = 20;
03302
03303   /* Check reference height... */
03304   if (ctl->hydz < 0)
03305     return;
03306
03307   /* Determine emitter index of H2O... */
03308   if (ig_h2o == -999)
03309     ig_h2o = find_emitter(ctl, "H2O");
03310
03311   /* Find air parcel next to reference height... */
03312   for (ip = 0; ip < atm->np; ip++)
03313     if (fabs(atm->z[ip] - ctl->hydz) < dzmin) {
03314       dzmin = fabs(atm->z[ip] - ctl->hydz);
03315       ipref = ip;
03316     }
03317
03318   /* Upper part of profile... */
03319   for (ip = ipref + 1; ip < atm->np; ip++) {
03320     mean = 0;
03321     for (i = 0; i < ipts; i++) {
03322       if (ig_h2o >= 0)
03323         e = LIN(0.0, atm->q[ig_h2o][ip - 1],
03324                 ipts - 1.0, atm->q[ig_h2o][ip], (double) i);
03325       mean += (e * mmh2o + (1 - e) * mmair)
03326         * G0 / RI
03327         / LIN(0.0, atm->t[ip - 1], ipts - 1.0, atm->t[ip], (double) i) / ipts;
03328     }
03329
03330     /* Compute p(z,T)... */
03331     atm->p[ip] =
03332       exp(log(atm->p[ip - 1]) - mean * 1000 * (atm->z[ip] - atm->z[ip - 1]));
03333   }
03334
03335   /* Lower part of profile... */
03336   for (ip = ipref - 1; ip >= 0; ip--) {
03337     mean = 0;
03338     for (i = 0; i < ipts; i++) {
03339       if (ig_h2o >= 0)
03340         e = LIN(0.0, atm->q[ig_h2o][ip + 1],
03341                 ipts - 1.0, atm->q[ig_h2o][ip], (double) i);
03342       mean += (e * mmh2o + (1 - e) * mmair)
```

```
03343         * G0 / RI
03344         / LIN(0.0, atm->t[ip + 1], ipts - 1.0, atm->t[ip], (double) i) / ipts;
03345     }
03346
03347     /* Compute p(z,T)... */
03348     atm->p[ip] =
03349       exp(log(atm->p[ip + 1]) - mean * 1000 * (atm->z[ip] - atm->z[ip + 1]));
03350   }
03351 }
03352
03353 /*****************************************************************************/
03354
03355 void idx2name(
03356   ctl_t * ctl,
03357   int idx,
03358   char *quantity) {
03359
03360   int ig, iw;
03361
03362   if (idx == IDXP)
03363     sprintf(quantity, "PRESSURE");
03364
03365   if (idx == IDXT)
03366     sprintf(quantity, "TEMPERATURE");
03367
03368   for (ig = 0; ig < ctl->ng; ig++)
03369     if (idx == IDXQ(ig))
03370       sprintf(quantity, "%s", ctl->emitter[ig]);
03371
03372   for (iw = 0; iw < ctl->nw; iw++)
03373     if (idx == IDXK(iw))
03374       sprintf(quantity, "EXTINCT_WINDOW%d", iw);
03375 }
03376
03377 /*****************************************************************************/
03378
03379 void init_tbl(
03380   ctl_t * ctl,
03381   tbl_t * tbl) {
03382
03383   FILE *in;
03384
03385   char filename[2 * LEN], line[LEN];
03386
03387   double eps, eps_old, press, press_old, temp, temp_old, u, u_old,
03388     f[NSHAPE], fsum, nu[NSHAPE];
03389
03390   int i, id, ig, ip, it, n;
03391
03392   /* Loop over trace gases and channels... */
03393   for (ig = 0; ig < ctl->ng; ig++)
03394 #pragma omp parallel for default(none) shared(ctl,tbl,ig) private(in,filename,line,eps,eps_old,press,
     press_old,temp,temp_old,u,u_old,id,ip,it)
03395     for (id = 0; id < ctl->nd; id++) {
03396
03397       /* Initialize... */
03398       tbl->np[ig][id] = -1;
03399       eps_old = -999;
03400       press_old = -999;
03401       temp_old = -999;
03402       u_old = -999;
03403
03404       /* Try to open file... */
03405       sprintf(filename, "%s_%.4f_%s.tab",
03406               ctl->tblbase, ctl->nu[id], ctl->emitter[ig]);
03407       if (!(in = fopen(filename, "r"))) {
03408         printf("Missing emissivity table: %s\n", filename);
03409         continue;
03410       }
03411       printf("Read emissivity table: %s\n", filename);
03412
03413       /* Read data... */
03414       while (fgets(line, LEN, in)) {
03415
03416         /* Parse line... */
03417         if (sscanf(line, "%lg %lg %lg %lg", &press, &temp, &u, &eps) != 4)
03418           continue;
03419
03420         /* Determine pressure index... */
03421         if (press != press_old) {
03422           press_old = press;
03423           if ((++tbl->np[ig][id]) >= TBLNP)
03424             ERRMSG("Too many pressure levels!");
03425           tbl->nt[ig][id][tbl->np[ig][id]] = -1;
03426         }
03427
03428         /* Determine temperature index... */
```

```
03429         if (temp != temp_old) {
03430           temp_old = temp;
03431           if ((++tbl->nt[ig][id][tbl->np[ig][id]]) >= TBLNT)
03432             ERRMSG("Too many temperatures!");
03433           tbl->nu[ig][id][tbl->np[ig][id]]
03434             [tbl->nt[ig][id][tbl->np[ig][id]]] = -1;
03435         }
03436
03437         /* Determine column density index... */
03438         if ((eps > eps_old && u > u_old) || tbl->nu[ig][id][tbl->np[ig][id]]
03439              [tbl->nt[ig][id][tbl->np[ig][id]]] < 0) {
03440           eps_old = eps;
03441           u_old = u;
03442           if ((++tbl->nu[ig][id][tbl->np[ig][id]]
03443                [tbl->nt[ig][id][tbl->np[ig][id]]]) >= TBLNU) {
03444             tbl->nu[ig][id][tbl->np[ig][id]]
03445               [tbl->nt[ig][id][tbl->np[ig][id]]]--;
03446             continue;
03447           }
03448         }
03449
03450         /* Store data... */
03451         tbl->p[ig][id][tbl->np[ig][id]] = press;
03452         tbl->t[ig][id][tbl->np[ig][id]][tbl->nt[ig][id][tbl->np[ig][id]]]
03453           = temp;
03454         tbl->u[ig][id][tbl->np[ig][id]][tbl->nt[ig][id][tbl->np[ig][id]]]
03455           [tbl->nu[ig][id][tbl->np[ig][id]]
03456            [tbl->nt[ig][id][tbl->np[ig][id]]]] = (float) u;
03457         tbl->eps[ig][id][tbl->np[ig][id]][tbl->nt[ig][id][tbl->np[ig][id]]]
03458           [tbl->nu[ig][id][tbl->np[ig][id]]
03459            [tbl->nt[ig][id][tbl->np[ig][id]]]] = (float) eps;
03460       }
03461
03462       /* Increment counters... */
03463       tbl->np[ig][id]++;
03464       for (ip = 0; ip < tbl->np[ig][id]; ip++) {
03465         tbl->nt[ig][id][ip]++;
03466         for (it = 0; it < tbl->nt[ig][id][ip]; it++)
03467           tbl->nu[ig][id][ip][it]++;
03468       }
03469
03470       /* Close file... */
03471       fclose(in);
03472     }
03473
03474   /* Write info... */
03475   printf("Initialize source function table...\n");
03476
03477   /* Loop over channels... */
03478 #pragma omp parallel for default(none) shared(ctl,tbl,ig) private(filename,it,i,n,f,fsum,nu)
03479   for (id = 0; id < ctl->nd; id++) {
03480
03481     /* Read filter function... */
03482     sprintf(filename, "%s_%.4f.filt", ctl->tblbase, ctl->nu[id]);
03483     read_shape(filename, nu, f, &n);
03484
03485     /* Compute source function table... */
03486     for (it = 0; it < TBLNS; it++) {
03487
03488       /* Set temperature... */
03489       tbl->st[it] = LIN(0.0, TMIN, TBLNS - 1.0, TMAX, (double) it);
03490
03491       /* Integrate Planck function... */
03492       fsum = 0;
03493       tbl->sr[id][it] = 0;
03494       for (i = 0; i < n; i++) {
03495         fsum += f[i];
03496         tbl->sr[id][it] += f[i] * planck(tbl->st[it], nu[i]);
03497       }
03498       tbl->sr[id][it] /= fsum;
03499     }
03500   }
03501 }
03502
03503 /*****************************************************************************/
03504
03505 void intpol_atm(
03506   ctl_t * ctl,
03507   atm_t * atm,
03508   double z,
03509   double *p,
03510   double *t,
03511   double *q,
03512   double *k) {
03513
03514   int ig, ip, iw;
03515
```

```
03516   /* Get array index... */
03517   ip = locate_irr(atm->z, atm->np, z);
03518
03519   /* Interpolate... */
03520   *p = EXP(atm->z[ip], atm->p[ip], atm->z[ip + 1], atm->p[ip + 1], z);
03521   *t = LIN(atm->z[ip], atm->t[ip], atm->z[ip + 1], atm->t[ip + 1], z);
03522   for (ig = 0; ig < ctl->ng; ig++)
03523     q[ig] =
03524       LIN(atm->z[ip], atm->q[ig][ip], atm->z[ip + 1], atm->q[ig][ip + 1], z);
03525   for (iw = 0; iw < ctl->nw; iw++)
03526     k[iw] =
03527       LIN(atm->z[ip], atm->k[iw][ip], atm->z[ip + 1], atm->k[iw][ip + 1], z);
03528 }
03529
03530 /*****************************************************************************/
03531
03532 void intpol_tbl(
03533   ctl_t * ctl,
03534   tbl_t * tbl,
03535   los_t * los,
03536   int ip,
03537   double tau_path[NG][ND],
03538   double tau_seg[ND]) {
03539
03540   double eps, eps00, eps01, eps10, eps11, u;
03541
03542   int id, ig, ipr, it0, it1;
03543
03544   /* Initialize... */
03545   if (ip <= 0)
03546     for (ig = 0; ig < ctl->ng; ig++)
03547       for (id = 0; id < ctl->nd; id++)
03548         tau_path[ig][id] = 1;
03549
03550   /* Loop over channels... */
03551   for (id = 0; id < ctl->nd; id++) {
03552
03553     /* Initialize... */
03554     tau_seg[id] = 1;
03555
03556     /* Loop over emitters.... */
03557     for (ig = 0; ig < ctl->ng; ig++) {
03558
03559       /* Check size of table (pressure)... */
03560       if (tbl->np[ig][id] < 2)
03561         eps = 0;
03562
03563       /* Check transmittance... */
03564       else if (tau_path[ig][id] < 1e-9)
03565         eps = 1;
03566
03567       /* Interpolate... */
03568       else {
03569
03570         /* Determine pressure and temperature indices... */
03571         ipr = locate_irr(tbl->p[ig][id], tbl->np[ig][id], los->p[ip]);
03572         it0 =
03573           locate_irr(tbl->t[ig][id][ipr], tbl->nt[ig][id][ipr], los->
    t[ip]);
03574         it1 =
03575           locate_reg(tbl->t[ig][id][ipr + 1], tbl->nt[ig][id][ipr + 1],
03576                      los->t[ip]);
03577
03578         /* Check size of table (temperature and column density)... */
03579         if (tbl->nt[ig][id][ipr] < 2 || tbl->nt[ig][id][ipr + 1] < 2
03580             || tbl->nu[ig][id][ipr][it0] < 2
03581             || tbl->nu[ig][id][ipr][it0 + 1] < 2
03582             || tbl->nu[ig][id][ipr + 1][it1] < 2
03583             || tbl->nu[ig][id][ipr + 1][it1 + 1] < 2)
03584           eps = 0;
03585
03586         else {
03587
03588           /* Get emissivities of extended path... */
03589           u = intpol_tbl_u(tbl, ig, id, ipr, it0, 1 - tau_path[ig][id]);
03590           eps00 = intpol_tbl_eps(tbl, ig, id, ipr, it0, u + los->u[ig][ip]);
03591
03592           u = intpol_tbl_u(tbl, ig, id, ipr, it0 + 1, 1 - tau_path[ig][id]);
03593           eps01 =
03594             intpol_tbl_eps(tbl, ig, id, ipr, it0 + 1, u + los->u[ig][ip]);
03595
03596           u = intpol_tbl_u(tbl, ig, id, ipr + 1, it1, 1 - tau_path[ig][id]);
03597           eps10 =
03598             intpol_tbl_eps(tbl, ig, id, ipr + 1, it1, u + los->u[ig][ip]);
03599
03600           u =
03601             intpol_tbl_u(tbl, ig, id, ipr + 1, it1 + 1, 1 - tau_path[ig][id]);
```

```
03602           eps11 =
03603             intpol_tbl_eps(tbl, ig, id, ipr + 1, it1 + 1, u + los->
    u[ig][ip]);
03604
03605           /* Interpolate with respect to temperature... */
03606           eps00 = LIN(tbl->t[ig][id][ipr][it0], eps00,
03607                       tbl->t[ig][id][ipr][it0 + 1], eps01, los->t[ip]);
03608           eps11 = LIN(tbl->t[ig][id][ipr + 1][it1], eps10,
03609                       tbl->t[ig][id][ipr + 1][it1 + 1], eps11, los->t[ip]);
03610
03611           /* Interpolate with respect to pressure... */
03612           eps00 = LIN(tbl->p[ig][id][ipr], eps00,
03613                       tbl->p[ig][id][ipr + 1], eps11, los->p[ip]);
03614
03615           /* Check emssivity range... */
03616           eps00 = GSL_MAX(GSL_MIN(eps00, 1), 0);
03617
03618           /* Determine segment emissivity... */
03619           eps = 1 - (1 - eps00) / tau_path[ig][id];
03620         }
03621       }
03622
03623       /* Get transmittance of extended path... */
03624       tau_path[ig][id] *= (1 - eps);
03625
03626       /* Get segment transmittance... */
03627       tau_seg[id] *= (1 - eps);
03628     }
03629   }
03630 }
03631
03632 /*****************************************************************************/
03633
03634 double intpol_tbl_eps(
03635   tbl_t * tbl,
03636   int ig,
03637   int id,
03638   int ip,
03639   int it,
03640   double u) {
03641
03642   int idx;
03643
03644   /* Lower boundary... */
03645   if (u < tbl->u[ig][id][ip][it][0])
03646     return LIN(0, 0, tbl->u[ig][id][ip][it][0], tbl->eps[ig][id][ip][it][0],
03647                u);
03648
03649   /* Upper boundary... */
03650   else if (u > tbl->u[ig][id][ip][it][tbl->nu[ig][id][ip][it] - 1])
03651     return LIN(tbl->u[ig][id][ip][it][tbl->nu[ig][id][ip][it] - 1],
03652                tbl->eps[ig][id][ip][it][tbl->nu[ig][id][ip][it] - 1],
03653                1e30, 1, u);
03654
03655   /* Interpolation... */
03656   else {
03657
03658     /* Get index... */
03659     idx = locate_tbl(tbl->u[ig][id][ip][it], tbl->nu[ig][id][ip][it], u);
03660
03661     /* Interpolate... */
03662     return
03663       LIN(tbl->u[ig][id][ip][it][idx], tbl->eps[ig][id][ip][it][idx],
03664           tbl->u[ig][id][ip][it][idx + 1], tbl->eps[ig][id][ip][it][idx + 1],
03665           u);
03666   }
03667 }
03668
03669 /*****************************************************************************/
03670
03671 double intpol_tbl_u(
03672   tbl_t * tbl,
03673   int ig,
03674   int id,
03675   int ip,
03676   int it,
03677   double eps) {
03678
03679   int idx;
03680
03681   /* Lower boundary... */
03682   if (eps < tbl->eps[ig][id][ip][it][0])
03683     return LIN(0, 0, tbl->eps[ig][id][ip][it][0], tbl->u[ig][id][ip][it][0],
03684                eps);
03685
03686   /* Upper boundary... */
03687   else if (eps > tbl->eps[ig][id][ip][it][tbl->nu[ig][id][ip][it] - 1])
```

```
03688     return LIN(tbl->eps[ig][id][ip][it][tbl->nu[ig][id][ip][it] - 1],
03689                tbl->u[ig][id][ip][it][tbl->nu[ig][id][ip][it] - 1],
03690                1, 1e30, eps);
03691
03692   /* Interpolation... */
03693   else {
03694
03695     /* Get index... */
03696     idx = locate_tbl(tbl->eps[ig][id][ip][it], tbl->nu[ig][id][ip][it], eps);
03697
03698     /* Interpolate... */
03699     return
03700       LIN(tbl->eps[ig][id][ip][it][idx], tbl->u[ig][id][ip][it][idx],
03701           tbl->eps[ig][id][ip][it][idx + 1], tbl->u[ig][id][ip][it][idx + 1],
03702           eps);
03703   }
03704 }
03705
03706 /*****************************************************************************/
03707
03708 void jsec2time(
03709   double jsec,
03710   int *year,
03711   int *mon,
03712   int *day,
03713   int *hour,
03714   int *min,
03715   int *sec,
03716   double *remain) {
03717
03718   struct tm t0, *t1;
03719
03720   time_t jsec0;
03721
03722   t0.tm_year = 100;
03723   t0.tm_mon = 0;
03724   t0.tm_mday = 1;
03725   t0.tm_hour = 0;
03726   t0.tm_min = 0;
03727   t0.tm_sec = 0;
03728
03729   jsec0 = (time_t) jsec + timegm(&t0);
03730   t1 = gmtime(&jsec0);
03731
03732   *year = t1->tm_year + 1900;
03733   *mon = t1->tm_mon + 1;
03734   *day = t1->tm_mday;
03735   *hour = t1->tm_hour;
03736   *min = t1->tm_min;
03737   *sec = t1->tm_sec;
03738   *remain = jsec - floor(jsec);
03739 }
03740
03741 /*****************************************************************************/
03742
03743 void kernel(
03744   ctl_t * ctl,
03745   atm_t * atm,
03746   obs_t * obs,
03747   gsl_matrix * k) {
03748
03749   atm_t *atm1;
03750   obs_t *obs1;
03751
03752   gsl_vector *x0, *x1, *yy0, *yy1;
03753
03754   int *iqa, j;
03755
03756   double h;
03757
03758   size_t i, n, m;
03759
03760   /* Get sizes... */
03761   m = k->size1;
03762   n = k->size2;
03763
03764   /* Allocate... */
03765   x0 = gsl_vector_alloc(n);
03766   yy0 = gsl_vector_alloc(m);
03767   ALLOC(iqa, int,
03768         N);
03769
03770   /* Compute radiance for undisturbed atmospheric data... */
03771   formod(ctl, atm, obs);
03772
03773   /* Compose vectors... */
03774   atm2x(ctl, atm, x0, iqa, NULL);
```

```
03775   obs2y(ctl, obs, yy0, NULL, NULL);
03776
03777   /* Initialize kernel matrix... */
03778   gsl_matrix_set_zero(k);
03779
03780   /* Loop over state vector elements... */
03781 #pragma omp parallel for default(none) shared(ctl,atm,obs,k,x0,yy0,n,m,iqa) private(i, j, h, x1, yy1, atm1,
       obs1)
03782   for (j = 0; j < (int) n; j++) {
03783
03784     /* Allocate... */
03785     x1 = gsl_vector_alloc(n);
03786     yy1 = gsl_vector_alloc(m);
03787     ALLOC(atm1, atm_t, 1);
03788     ALLOC(obs1, obs_t, 1);
03789
03790     /* Set perturbation size... */
03791     if (iqa[j] == IDXP)
03792       h = GSL_MAX(fabs(0.01 * gsl_vector_get(x0, (size_t) j)), 1e-7);
03793     else if (iqa[j] == IDXT)
03794       h = 1;
03795     else if (iqa[j] >= IDXQ(0) && iqa[j] < IDXQ(ctl->ng))
03796       h = GSL_MAX(fabs(0.01 * gsl_vector_get(x0, (size_t) j)), 1e-15);
03797     else if (iqa[j] >= IDXK(0) && iqa[j] < IDXK(ctl->nw))
03798       h = 1e-4;
03799     else
03800       ERRMSG("Cannot set perturbation size!");
03801
03802     /* Disturb state vector element... */
03803     gsl_vector_memcpy(x1, x0);
03804     gsl_vector_set(x1, (size_t) j, gsl_vector_get(x1, (size_t) j) + h);
03805     copy_atm(ctl, atm1, atm, 0);
03806     copy_obs(ctl, obs1, obs, 0);
03807     x2atm(ctl, x1, atm1);
03808
03809     /* Compute radiance for disturbed atmospheric data... */
03810     formod(ctl, atm1, obs1);
03811
03812     /* Compose measurement vector for disturbed radiance data... */
03813     obs2y(ctl, obs1, yy1, NULL, NULL);
03814
03815     /* Compute derivatives... */
03816     for (i = 0; i < m; i++)
03817       gsl_matrix_set(k, i, (size_t) j,
03818                      (gsl_vector_get(yy1, i) - gsl_vector_get(yy0, i)) / h);
03819
03820     /* Free... */
03821     gsl_vector_free(x1);
03822     gsl_vector_free(yy1);
03823     free(atm1);
03824     free(obs1);
03825   }
03826
03827   /* Free... */
03828   gsl_vector_free(x0);
03829   gsl_vector_free(yy0);
03830   free(iqa);
03831 }
03832
03833 /*****************************************************************************/
03834
03835 int locate_irr(
03836   double *xx,
03837   int n,
03838   double x) {
03839
03840   int i, ilo, ihi;
03841
03842   ilo = 0;
03843   ihi = n - 1;
03844   i = (ihi + ilo) >> 1;
03845
03846   if (xx[i] < xx[i + 1])
03847     while (ihi > ilo + 1) {
03848       i = (ihi + ilo) >> 1;
03849       if (xx[i] > x)
03850         ihi = i;
03851       else
03852         ilo = i;
03853   } else
03854     while (ihi > ilo + 1) {
03855       i = (ihi + ilo) >> 1;
03856       if (xx[i] <= x)
03857         ihi = i;
03858       else
03859         ilo = i;
03860     }
```

```
03861
03862   return ilo;
03863 }
03864
03865 /*****************************************************************************/
03866
03867 int locate_reg(
03868   double *xx,
03869   int n,
03870   double x) {
03871
03872   int i;
03873
03874   /* Calculate index... */
03875   i = (int) ((x - xx[0]) / (xx[1] - xx[0]));
03876
03877   /* Check range... */
03878   if (i < 0)
03879     i = 0;
03880   else if (i >= n - 2)
03881     i = n - 2;
03882
03883   return i;
03884 }
03885
03886 /*****************************************************************************/
03887
03888 int locate_tbl(
03889   float *xx,
03890   int n,
03891   double x) {
03892
03893   int i, ilo, ihi;
03894
03895   ilo = 0;
03896   ihi = n - 1;
03897   i = (ihi + ilo) >> 1;
03898
03899   while (ihi > ilo + 1) {
03900     i = (ihi + ilo) >> 1;
03901     if (xx[i] > x)
03902       ihi = i;
03903     else
03904       ilo = i;
03905   }
03906
03907   return ilo;
03908 }
03909
03910 /*****************************************************************************/
03911
03912 size_t obs2y(
03913   ctl_t * ctl,
03914   obs_t * obs,
03915   gsl_vector * y,
03916   int *ida,
03917   int *ira) {
03918
03919   int id, ir;
03920
03921   size_t m = 0;
03922
03923   /* Determine measurement vector... */
03924   for (ir = 0; ir < obs->nr; ir++)
03925     for (id = 0; id < ctl->nd; id++)
03926       if (gsl_finite(obs->rad[id][ir])) {
03927         if (y != NULL)
03928           gsl_vector_set(y, m, obs->rad[id][ir]);
03929         if (ida != NULL)
03930           ida[m] = id;
03931         if (ira != NULL)
03932           ira[m] = ir;
03933         m++;
03934       }
03935
03936   return m;
03937 }
03938
03939 /*****************************************************************************/
03940
03941 double planck(
03942   double t,
03943   double nu) {
03944
03945   return C1 * POW3(nu) / gsl_expm1(C2 * nu / t);
03946 }
03947
```

```
03948 /*****************************************************************************/
03949
03950 void raytrace(
03951   ctl_t * ctl,
03952   atm_t * atm,
03953   obs_t * obs,
03954   los_t * los,
03955   int ir) {
03956
03957   double cosa, d, dmax, dmin = 0, ds, ex0[3], ex1[3], frac, h = 0.02, k[NW],
03958     lat, lon, n, naux, ng[3], norm, p, q[NG], t, x[3], xh[3],
03959     xobs[3], xvp[3], z = 1e99, zmax, zmin, zrefrac = 60;
03960
03961   int i, ig, ip, iw, stop = 0;
03962
03963   /* Initialize... */
03964   los->np = 0;
03965   los->tsurf = -999;
03966   obs->tpz[ir] = obs->vpz[ir];
03967   obs->tplon[ir] = obs->vplon[ir];
03968   obs->tplat[ir] = obs->vplat[ir];
03969
03970   /* Get altitude range of atmospheric data... */
03971   gsl_stats_minmax(&zmin, &zmax, atm->z, 1, (size_t) atm->np);
03972
03973   /* Check observer altitude... */
03974   if (obs->obsz[ir] < zmin)
03975     ERRMSG("Observer below surface!");
03976
03977   /* Check view point altitude... */
03978   if (obs->vpz[ir] > zmax)
03979     return;
03980
03981   /* Determine Cartesian coordinates for observer and view point... */
03982   geo2cart(obs->obsz[ir], obs->obslon[ir], obs->obslat[ir], xobs);
03983   geo2cart(obs->vpz[ir], obs->vplon[ir], obs->vplat[ir], xvp);
03984
03985   /* Determine initial tangent vector... */
03986   for (i = 0; i < 3; i++)
03987     ex0[i] = xvp[i] - xobs[i];
03988   norm = NORM(ex0);
03989   for (i = 0; i < 3; i++)
03990     ex0[i] /= norm;
03991
03992   /* Observer within atmosphere... */
03993   for (i = 0; i < 3; i++)
03994     x[i] = xobs[i];
03995
03996   /* Observer above atmosphere (search entry point)... */
03997   if (obs->obsz[ir] > zmax) {
03998     dmax = norm;
03999     while (fabs(dmin - dmax) > 0.001) {
04000       d = (dmax + dmin) / 2;
04001       for (i = 0; i < 3; i++)
04002         x[i] = xobs[i] + d * ex0[i];
04003       cart2geo(x, &z, &lon, &lat);
04004       if (z <= zmax && z > zmax - 0.001)
04005         break;
04006       if (z < zmax - 0.0005)
04007         dmax = d;
04008       else
04009         dmin = d;
04010     }
04011   }
04012
04013   /* Ray-tracing... */
04014   while (1) {
04015
04016     /* Set step length... */
04017     ds = ctl->rayds;
04018     if (ctl->raydz > 0) {
04019       norm = NORM(x);
04020       for (i = 0; i < 3; i++)
04021         xh[i] = x[i] / norm;
04022       cosa = fabs(DOTP(ex0, xh));
04023       if (cosa != 0)
04024         ds = GSL_MIN(ctl->rayds, ctl->raydz / cosa);
04025     }
04026
04027     /* Determine geolocation... */
04028     cart2geo(x, &z, &lon, &lat);
04029
04030     /* Check if LOS hits the ground or has left atmosphere... */
04031     if (z < zmin || z > zmax) {
04032       stop = (z < zmin ? 2 : 1);
04033       frac =
04034         ((z <
```

```
04035           zmin ? zmin : zmax) - los->z[los->np - 1]) / (z - los->z[los->np -
04036                                                                       1]);
04037       geo2cart(los->z[los->np - 1], los->lon[los->np - 1],
04038                los->lat[los->np - 1], xh);
04039       for (i = 0; i < 3; i++)
04040         x[i] = xh[i] + frac * (x[i] - xh[i]);
04041       cart2geo(x, &z, &lon, &lat);
04042       los->ds[los->np - 1] = ds * frac;
04043       ds = 0;
04044     }
04045
04046     /* Interpolate atmospheric data... */
04047     intpol_atm(ctl, atm, z, &p, &t, q, k);
04048
04049     /* Save data... */
04050     los->lon[los->np] = lon;
04051     los->lat[los->np] = lat;
04052     los->z[los->np] = z;
04053     los->p[los->np] = p;
04054     los->t[los->np] = t;
04055     for (ig = 0; ig < ctl->ng; ig++)
04056       los->q[ig][los->np] = q[ig];
04057     for (iw = 0; iw < ctl->nw; iw++)
04058       los->k[iw][los->np] = k[iw];
04059     los->ds[los->np] = ds;
04060
04061     /* Increment and check number of LOS points... */
04062     if ((++los->np) > NLOS)
04063       ERRMSG("Too many LOS points!");
04064
04065     /* Check stop flag... */
04066     if (stop) {
04067       los->tsurf = (stop == 2 ? t : -999);
04068       break;
04069     }
04070
04071     /* Determine refractivity... */
04072     if (ctl->refrac && z <= zrefrac)
04073       n = 1 + refractivity(p, t);
04074     else
04075       n = 1;
04076
04077     /* Construct new tangent vector (first term)... */
04078     for (i = 0; i < 3; i++)
04079       ex1[i] = ex0[i] * n;
04080
04081     /* Compute gradient of refractivity... */
04082     if (ctl->refrac && z <= zrefrac) {
04083       for (i = 0; i < 3; i++)
04084         xh[i] = x[i] + 0.5 * ds * ex0[i];
04085       cart2geo(xh, &z, &lon, &lat);
04086       intpol_atm(ctl, atm, z, &p, &t, q, k);
04087       n = refractivity(p, t);
04088       for (i = 0; i < 3; i++) {
04089         xh[i] += h;
04090         cart2geo(xh, &z, &lon, &lat);
04091         intpol_atm(ctl, atm, z, &p, &t, q, k);
04092         naux = refractivity(p, t);
04093         ng[i] = (naux - n) / h;
04094         xh[i] -= h;
04095       }
04096     } else
04097       for (i = 0; i < 3; i++)
04098         ng[i] = 0;
04099
04100     /* Construct new tangent vector (second term)... */
04101     for (i = 0; i < 3; i++)
04102       ex1[i] += ds * ng[i];
04103
04104     /* Normalize new tangent vector... */
04105     norm = NORM(ex1);
04106     for (i = 0; i < 3; i++)
04107       ex1[i] /= norm;
04108
04109     /* Determine next point of LOS... */
04110     for (i = 0; i < 3; i++)
04111       x[i] += 0.5 * ds * (ex0[i] + ex1[i]);
04112
04113     /* Copy tangent vector... */
04114     for (i = 0; i < 3; i++)
04115       ex0[i] = ex1[i];
04116   }
04117
04118   /* Get tangent point (to be done before changing segment lengths!)... */
04119   tangent_point(los, &obs->tpz[ir], &obs->tplon[ir], &obs->
      tplat[ir]);
04120
```

```
04121   /* Change segment lengths according to trapezoid rule... */
04122   for (ip = los->np - 1; ip >= 1; ip--)
04123     los->ds[ip] = 0.5 * (los->ds[ip - 1] + los->ds[ip]);
04124   los->ds[0] *= 0.5;
04125
04126   /* Compute column density... */
04127   for (ip = 0; ip < los->np; ip++)
04128     for (ig = 0; ig < ctl->ng; ig++)
04129       los->u[ig][ip] = 10 * los->q[ig][ip] * los->p[ip]
04130         / (KB * los->t[ip]) * los->ds[ip];
04131 }
04132
04133 /*****************************************************************************/
04134
04135 void read_atm(
04136   const char *dirname,
04137   const char *filename,
04138   ctl_t * ctl,
04139   atm_t * atm) {
04140
04141   FILE *in;
04142
04143   char file[LEN], line[LEN], *tok;
04144
04145   int ig, iw;
04146
04147   /* Init... */
04148   atm->np = 0;
04149
04150   /* Set filename... */
04151   if (dirname != NULL)
04152     sprintf(file, "%s/%s", dirname, filename);
04153   else
04154     sprintf(file, "%s", filename);
04155
04156   /* Write info... */
04157   printf("Read atmospheric data: %s\n", file);
04158
04159   /* Open file... */
04160   if (!(in = fopen(file, "r")))
04161     ERRMSG("Cannot open file!");
04162
04163   /* Read line... */
04164   while (fgets(line, LEN, in)) {
04165
04166     /* Read data... */
04167     TOK(line, tok, "%lg", atm->time[atm->np]);
04168     TOK(NULL, tok, "%lg", atm->z[atm->np]);
04169     TOK(NULL, tok, "%lg", atm->lon[atm->np]);
04170     TOK(NULL, tok, "%lg", atm->lat[atm->np]);
04171     TOK(NULL, tok, "%lg", atm->p[atm->np]);
04172     TOK(NULL, tok, "%lg", atm->t[atm->np]);
04173     for (ig = 0; ig < ctl->ng; ig++)
04174       TOK(NULL, tok, "%lg", atm->q[ig][atm->np]);
04175     for (iw = 0; iw < ctl->nw; iw++)
04176       TOK(NULL, tok, "%lg", atm->k[iw][atm->np]);
04177
04178     /* Increment data point counter... */
04179     if ((++atm->np) > NP)
04180       ERRMSG("Too many data points!");
04181   }
04182
04183   /* Close file... */
04184   fclose(in);
04185
04186   /* Check number of points... */
04187   if (atm->np < 1)
04188     ERRMSG("Could not read any data!");
04189 }
04190
04191 /*****************************************************************************/
04192
04193 void read_ctl(
04194   int argc,
04195   char *argv[],
04196   ctl_t * ctl) {
04197
04198   int id, ig, iw;
04199
04200   /* Write info... */
04201   printf("\nJuelich Rapid Spectral Simulation Code (JURASSIC)\n"
04202          "(executable: %s | compiled: %s, %s)\n\n",
04203          argv[0], __DATE__, __TIME__);
04204
04205   /* Emitters... */
04206   ctl->ng = (int) scan_ctl(argc, argv, "NG", -1, "0", NULL);
04207   if (ctl->ng < 0 || ctl->ng > NG)
```

```
04208     ERRMSG("Set 0 <= NG <= MAX!");
04209   for (ig = 0; ig < ctl->ng; ig++)
04210     scan_ctl(argc, argv, "EMITTER", ig, "", ctl->emitter[ig]);
04211
04212   /* Radiance channels... */
04213   ctl->nd = (int) scan_ctl(argc, argv, "ND", -1, "0", NULL);
04214   if (ctl->nd < 0 || ctl->nd > ND)
04215     ERRMSG("Set 0 <= ND <= MAX!");
04216   for (id = 0; id < ctl->nd; id++)
04217     ctl->nu[id] = scan_ctl(argc, argv, "NU", id, "", NULL);
04218
04219   /* Spectral windows... */
04220   ctl->nw = (int) scan_ctl(argc, argv, "NW", -1, "1", NULL);
04221   if (ctl->nw < 0 || ctl->nw > NW)
04222     ERRMSG("Set 0 <= NW <= MAX!");
04223   for (id = 0; id < ctl->nd; id++)
04224     ctl->window[id] = (int) scan_ctl(argc, argv, "WINDOW", id, "0", NULL);
04225
04226   /* Emissivity look-up tables... */
04227   scan_ctl(argc, argv, "TBLBASE", -1, "-", ctl->tblbase);
04228
04229   /* Hydrostatic equilibrium... */
04230   ctl->hydz = scan_ctl(argc, argv, "HYDZ", -1, "-999", NULL);
04231
04232   /* Continua... */
04233   ctl->ctm_co2 = (int) scan_ctl(argc, argv, "CTM_CO2", -1, "1", NULL);
04234   ctl->ctm_h2o = (int) scan_ctl(argc, argv, "CTM_H2O", -1, "1", NULL);
04235   ctl->ctm_n2 = (int) scan_ctl(argc, argv, "CTM_N2", -1, "1", NULL);
04236   ctl->ctm_o2 = (int) scan_ctl(argc, argv, "CTM_O2", -1, "1", NULL);
04237
04238   /* Ray-tracing... */
04239   ctl->refrac = (int) scan_ctl(argc, argv, "REFRAC", -1, "1", NULL);
04240   ctl->rayds = scan_ctl(argc, argv, "RAYDS", -1, "10", NULL);
04241   ctl->raydz = scan_ctl(argc, argv, "RAYDZ", -1, "0.5", NULL);
04242
04243   /* Field of view... */
04244   scan_ctl(argc, argv, "FOV", -1, "-", ctl->fov);
04245
04246   /* Retrieval interface... */
04247   ctl->retp_zmin = scan_ctl(argc, argv, "RETP_ZMIN", -1, "-999", NULL);
04248   ctl->retp_zmax = scan_ctl(argc, argv, "RETP_ZMAX", -1, "-999", NULL);
04249   ctl->rett_zmin = scan_ctl(argc, argv, "RETT_ZMIN", -1, "-999", NULL);
04250   ctl->rett_zmax = scan_ctl(argc, argv, "RETT_ZMAX", -1, "-999", NULL);
04251   for (ig = 0; ig < ctl->ng; ig++) {
04252     ctl->retq_zmin[ig] = scan_ctl(argc, argv, "RETQ_ZMIN", ig, "-999", NULL);
04253     ctl->retq_zmax[ig] = scan_ctl(argc, argv, "RETQ_ZMAX", ig, "-999", NULL);
04254   }
04255   for (iw = 0; iw < ctl->nw; iw++) {
04256     ctl->retk_zmin[iw] = scan_ctl(argc, argv, "RETK_ZMIN", iw, "-999", NULL);
04257     ctl->retk_zmax[iw] = scan_ctl(argc, argv, "RETK_ZMAX", iw, "-999", NULL);
04258   }
04259
04260   /* Output flags... */
04261   ctl->write_bbt = (int) scan_ctl(argc, argv, "WRITE_BBT", -1, "0", NULL);
04262   ctl->write_matrix =
04263     (int) scan_ctl(argc, argv, "WRITE_MATRIX", -1, "0", NULL);
04264 }
04265
04266 /*****************************************************************************/
04267
04268 void read_matrix(
04269   const char *dirname,
04270   const char *filename,
04271   gsl_matrix * matrix) {
04272
04273   FILE *in;
04274
04275   char dum[LEN], file[LEN], line[LEN];
04276
04277   double value;
04278
04279   int i, j;
04280
04281   /* Set filename... */
04282   if (dirname != NULL)
04283     sprintf(file, "%s/%s", dirname, filename);
04284   else
04285     sprintf(file, "%s", filename);
04286
04287   /* Write info... */
04288   printf("Read matrix: %s\n", file);
04289
04290   /* Open file... */
04291   if (!(in = fopen(file, "r")))
04292     ERRMSG("Cannot open file!");
04293
04294   /* Read data... */
```

```
04295   gsl_matrix_set_zero(matrix);
04296   while (fgets(line, LEN, in))
04297     if (sscanf(line, "%d %s %s %s %s %s %d %s %s %s %s %s %lg",
04298                &i, dum, dum, dum, dum, dum,
04299                &j, dum, dum, dum, dum, dum, &value) == 13)
04300       gsl_matrix_set(matrix, (size_t) i, (size_t) j, value);
04301
04302   /* Close file... */
04303   fclose(in);
04304 }
04305
04306 /*****************************************************************************/
04307
04308 void read_obs(
04309   const char *dirname,
04310   const char *filename,
04311   ctl_t * ctl,
04312   obs_t * obs) {
04313
04314   FILE *in;
04315
04316   char file[LEN], line[LEN], *tok;
04317
04318   int id;
04319
04320   /* Init... */
04321   obs->nr = 0;
04322
04323   /* Set filename... */
04324   if (dirname != NULL)
04325     sprintf(file, "%s/%s", dirname, filename);
04326   else
04327     sprintf(file, "%s", filename);
04328
04329   /* Write info... */
04330   printf("Read observation data: %s\n", file);
04331
04332   /* Open file... */
04333   if (!(in = fopen(file, "r")))
04334     ERRMSG("Cannot open file!");
04335
04336   /* Read line... */
04337   while (fgets(line, LEN, in)) {
04338
04339     /* Read data... */
04340     TOK(line, tok, "%lg", obs->time[obs->nr]);
04341     TOK(NULL, tok, "%lg", obs->obsz[obs->nr]);
04342     TOK(NULL, tok, "%lg", obs->obslon[obs->nr]);
04343     TOK(NULL, tok, "%lg", obs->obslat[obs->nr]);
04344     TOK(NULL, tok, "%lg", obs->vpz[obs->nr]);
04345     TOK(NULL, tok, "%lg", obs->vplon[obs->nr]);
04346     TOK(NULL, tok, "%lg", obs->vplat[obs->nr]);
04347     TOK(NULL, tok, "%lg", obs->tpz[obs->nr]);
04348     TOK(NULL, tok, "%lg", obs->tplon[obs->nr]);
04349     TOK(NULL, tok, "%lg", obs->tplat[obs->nr]);
04350     for (id = 0; id < ctl->nd; id++)
04351       TOK(NULL, tok, "%lg", obs->rad[id][obs->nr]);
04352     for (id = 0; id < ctl->nd; id++)
04353       TOK(NULL, tok, "%lg", obs->tau[id][obs->nr]);
04354
04355     /* Increment counter... */
04356     if ((++obs->nr) > NR)
04357       ERRMSG("Too many rays!");
04358   }
04359
04360   /* Close file... */
04361   fclose(in);
04362
04363   /* Check number of points... */
04364   if (obs->nr < 1)
04365     ERRMSG("Could not read any data!");
04366 }
04367
04368 /*****************************************************************************/
04369
04370 void read_shape(
04371   const char *filename,
04372   double *x,
04373   double *y,
04374   int *n) {
04375
04376   FILE *in;
04377
04378   char line[LEN];
04379
04380   /* Write info... */
04381   printf("Read shape function: %s\n", filename);
```

```
04382
04383   /* Open file... */
04384   if (!(in = fopen(filename, "r")))
04385     ERRMSG("Cannot open file!");
04386
04387   /* Read data... */
04388   *n = 0;
04389   while (fgets(line, LEN, in))
04390     if (sscanf(line, "%lg %lg", &x[*n], &y[*n]) == 2)
04391       if ((++(*n)) > NSHAPE)
04392         ERRMSG("Too many data points!");
04393
04394   /* Check number of points... */
04395   if (*n < 1)
04396     ERRMSG("Could not read any data!");
04397
04398   /* Close file... */
04399   fclose(in);
04400 }
04401
04402 /*****************************************************************************/
04403
04404 double refractivity(
04405   double p,
04406   double t) {
04407
04408   /* Refractivity of air at 4 to 15 micron... */
04409   return 7.753e-05 * p / t;
04410 }
04411
04412 /*****************************************************************************/
04413
04414 double scan_ctl(
04415   int argc,
04416   char *argv[],
04417   const char *varname,
04418   int arridx,
04419   const char *defvalue,
04420   char *value) {
04421
04422   FILE *in = NULL;
04423
04424   char dummy[LEN], fullname1[LEN], fullname2[LEN], line[LEN],
04425     msg[2 * LEN], rvarname[LEN], rval[LEN];
04426
04427   int contain = 0, i;
04428
04429   /* Open file... */
04430   if (argv[1][0] != '-')
04431     if (!(in = fopen(argv[1], "r")))
04432       ERRMSG("Cannot open file!");
04433
04434   /* Set full variable name... */
04435   if (arridx >= 0) {
04436     sprintf(fullname1, "%s[%d]", varname, arridx);
04437     sprintf(fullname2, "%s[*]", varname);
04438   } else {
04439     sprintf(fullname1, "%s", varname);
04440     sprintf(fullname2, "%s", varname);
04441   }
04442
04443   /* Read data... */
04444   if (in != NULL)
04445     while (fgets(line, LEN, in))
04446       if (sscanf(line, "%s %s %s", rvarname, dummy, rval) == 3)
04447         if (strcasecmp(rvarname, fullname1) == 0 ||
04448             strcasecmp(rvarname, fullname2) == 0) {
04449           contain = 1;
04450           break;
04451         }
04452   for (i = 1; i < argc - 1; i++)
04453     if (strcasecmp(argv[i], fullname1) == 0 ||
04454         strcasecmp(argv[i], fullname2) == 0) {
04455       sprintf(rval, "%s", argv[i + 1]);
04456       contain = 1;
04457       break;
04458     }
04459
04460   /* Close file... */
04461   if (in != NULL)
04462     fclose(in);
04463
04464   /* Check for missing variables... */
04465   if (!contain) {
04466     if (strlen(defvalue) > 0)
04467       sprintf(rval, "%s", defvalue);
04468     else {
```

```
04469       sprintf(msg, "Missing variable %s!\n", fullname1);
04470       ERRMSG(msg);
04471     }
04472   }
04473
04474   /* Write info... */
04475   printf("%s = %s\n", fullname1, rval);
04476
04477   /* Return values... */
04478   if (value != NULL)
04479     sprintf(value, "%s", rval);
04480   return atof(rval);
04481 }
04482
04483 /*****************************************************************************/
04484
04485 void tangent_point(
04486   los_t * los,
04487   double *tpz,
04488   double *tplon,
04489   double *tplat) {
04490
04491   double a, b, c, dummy, v[3], v0[3], v2[3], x, x1, x2, yy0, yy1, yy2;
04492
04493   size_t i, ip;
04494
04495   /* Find minimum altitude... */
04496   ip = gsl_stats_min_index(los->z, 1, (size_t) los->np);
04497
04498   /* Nadir or zenith... */
04499   if (ip <= 0 || ip >= (size_t) los->np - 1) {
04500     *tpz = los->z[los->np - 1];
04501     *tplon = los->lon[los->np - 1];
04502     *tplat = los->lat[los->np - 1];
04503   }
04504
04505   /* Limb... */
04506   else {
04507
04508     /* Determine interpolating polynomial y=a*x^2+b*x+c... */
04509     yy0 = los->z[ip - 1];
04510     yy1 = los->z[ip];
04511     yy2 = los->z[ip + 1];
04512     x1 = sqrt(POW2(los->ds[ip]) - POW2(yy1 - yy0));
04513     x2 = x1 + sqrt(POW2(los->ds[ip + 1]) - POW2(yy2 - yy1));
04514     a = 1 / (x1 - x2) * (-(yy0 - yy1) / x1 + (yy0 - yy2) / x2);
04515     b = -(yy0 - yy1) / x1 - a * x1;
04516     c = yy0;
04517
04518     /* Get tangent point location... */
04519     x = -b / (2 * a);
04520     *tpz = a * x * x + b * x + c;
04521     geo2cart(los->z[ip - 1], los->lon[ip - 1], los->lat[ip - 1], v0);
04522     geo2cart(los->z[ip + 1], los->lon[ip + 1], los->lat[ip + 1], v2);
04523     for (i = 0; i < 3; i++)
04524       v[i] = LIN(0.0, v0[i], x2, v2[i], x);
04525     cart2geo(v, &dummy, tplon, tplat);
04526   }
04527 }
04528
04529 /*****************************************************************************/
04530
04531 void time2jsec(
04532   int year,
04533   int mon,
04534   int day,
04535   int hour,
04536   int min,
04537   int sec,
04538   double remain,
04539   double *jsec) {
04540
04541   struct tm t0, t1;
04542
04543   t0.tm_year = 100;
04544   t0.tm_mon = 0;
04545   t0.tm_mday = 1;
04546   t0.tm_hour = 0;
04547   t0.tm_min = 0;
04548   t0.tm_sec = 0;
04549
04550   t1.tm_year = year - 1900;
04551   t1.tm_mon = mon - 1;
04552   t1.tm_mday = day;
04553   t1.tm_hour = hour;
04554   t1.tm_min = min;
04555   t1.tm_sec = sec;
```

```
04556
04557   *jsec = (double) timegm(&t1) - (double) timegm(&t0) + remain;
04558 }
04559
04560 /*****************************************************************************/
04561
04562 void timer(
04563   const char *name,
04564   const char *file,
04565   const char *func,
04566   int line,
04567   int mode) {
04568
04569   static double w0[10];
04570
04571   static int l0[10], nt;
04572
04573   /* Start new timer... */
04574   if (mode == 1) {
04575     w0[nt] = omp_get_wtime();
04576     l0[nt] = line;
04577     if ((++nt) >= 10)
04578       ERRMSG("Too many timers!");
04579   }
04580
04581   /* Write elapsed time... */
04582   else {
04583
04584     /* Check timer index... */
04585     if (nt - 1 < 0)
04586       ERRMSG("Coding error!");
04587
04588     /* Write elapsed time... */
04589     printf("Timer '%s' (%s, %s, l%d-%d): %.3f sec\n",
04590            name, file, func, l0[nt - 1], line, omp_get_wtime() - w0[nt - 1]);
04591   }
04592
04593   /* Stop timer... */
04594   if (mode == 3)
04595     nt--;
04596 }
04597
04598 /*****************************************************************************/
04599
04600 void write_atm(
04601   const char *dirname,
04602   const char *filename,
04603   ctl_t * ctl,
04604   atm_t * atm) {
04605
04606   FILE *out;
04607
04608   char file[LEN];
04609
04610   int ig, ip, iw, n = 6;
04611
04612   /* Set filename... */
04613   if (dirname != NULL)
04614     sprintf(file, "%s/%s", dirname, filename);
04615   else
04616     sprintf(file, "%s", filename);
04617
04618   /* Write info... */
04619   printf("Write atmospheric data: %s\n", file);
04620
04621   /* Create file... */
04622   if (!(out = fopen(file, "w")))
04623     ERRMSG("Cannot create file!");
04624
04625   /* Write header... */
04626   fprintf(out,
04627           "# $1 = time (seconds since 2000-01-01T00:00Z)\n"
04628           "# $2 = altitude [km]\n"
04629           "# $3 = longitude [deg]\n"
04630           "# $4 = latitude [deg]\n"
04631           "# $5 = pressure [hPa]\n" "# $6 = temperature [K]\n");
04632   for (ig = 0; ig < ctl->ng; ig++)
04633     fprintf(out, "# $%d = %s volume mixing ratio\n", ++n, ctl->emitter[ig]);
04634   for (iw = 0; iw < ctl->nw; iw++)
04635     fprintf(out, "# $%d = window %d: extinction [1/km]\n", ++n, iw);
04636
04637   /* Write data... */
04638   for (ip = 0; ip < atm->np; ip++) {
04639     if (ip == 0 || atm->lat[ip] != atm->lat[ip - 1]
04640         || atm->lon[ip] != atm->lon[ip - 1])
04641       fprintf(out, "\n");
04642     fprintf(out, "%.2f %g %g %g %g %g", atm->time[ip], atm->z[ip],
```

```
04643             atm->lon[ip], atm->lat[ip], atm->p[ip], atm->t[ip]);
04644     for (ig = 0; ig < ctl->ng; ig++)
04645       fprintf(out, " %g", atm->q[ig][ip]);
04646     for (iw = 0; iw < ctl->nw; iw++)
04647       fprintf(out, " %g", atm->k[iw][ip]);
04648     fprintf(out, "\n");
04649   }
04650
04651   /* Close file... */
04652   fclose(out);
04653 }
04654
04655 /*****************************************************************************/
04656
04657 void write_matrix(
04658   const char *dirname,
04659   const char *filename,
04660   ctl_t * ctl,
04661   gsl_matrix * matrix,
04662   atm_t * atm,
04663   obs_t * obs,
04664   const char *rowspace,
04665   const char *colspace,
04666   const char *sort) {
04667
04668   FILE *out;
04669
04670   char file[LEN], quantity[LEN];
04671
04672   int *cida, *ciqa, *cipa, *cira, *rida, *riqa, *ripa, *rira;
04673
04674   size_t i, j, nc, nr;
04675
04676   /* Check output flag... */
04677   if (!ctl->write_matrix)
04678     return;
04679
04680   /* Allocate... */
04681   ALLOC(cida, int, M);
04682   ALLOC(ciqa, int,
04683         N);
04684   ALLOC(cipa, int,
04685         N);
04686   ALLOC(cira, int,
04687         M);
04688   ALLOC(rida, int,
04689         M);
04690   ALLOC(riqa, int,
04691         N);
04692   ALLOC(ripa, int,
04693         N);
04694   ALLOC(rira, int,
04695         M);
04696
04697   /* Set filename... */
04698   if (dirname != NULL)
04699     sprintf(file, "%s/%s", dirname, filename);
04700   else
04701     sprintf(file, "%s", filename);
04702
04703   /* Write info... */
04704   printf("Write matrix: %s\n", file);
04705
04706   /* Create file... */
04707   if (!(out = fopen(file, "w")))
04708     ERRMSG("Cannot create file!");
04709
04710   /* Write header (row space)... */
04711   if (rowspace[0] == 'y') {
04712
04713     fprintf(out,
04714             "# $1 = Row: index (measurement space)\n"
04715             "# $2 = Row: channel wavenumber [cm^-1]\n"
04716             "# $3 = Row: time (seconds since 2000-01-01T00:00Z)\n"
04717             "# $4 = Row: view point altitude [km]\n"
04718             "# $5 = Row: view point longitude [deg]\n"
04719             "# $6 = Row: view point latitude [deg]\n");
04720
04721     /* Get number of rows... */
04722     nr = obs2y(ctl, obs, NULL, rida, rira);
04723
04724   } else {
04725
04726     fprintf(out,
04727             "# $1 = Row: index (state space)\n"
04728             "# $2 = Row: name of quantity\n"
04729             "# $3 = Row: time (seconds since 2000-01-01T00:00Z)\n"
```

```
04730             "# $4 = Row: altitude [km]\n"
04731             "# $5 = Row: longitude [deg]\n" "# $6 = Row: latitude [deg]\n");
04732
04733     /* Get number of rows... */
04734     nr = atm2x(ctl, atm, NULL, riqa, ripa);
04735   }
04736
04737   /* Write header (column space)... */
04738   if (colspace[0] == 'y') {
04739
04740     fprintf(out,
04741             "# $7 = Col: index (measurement space)\n"
04742             "# $8 = Col: channel wavenumber [cm^-1]\n"
04743             "# $9 = Col: time (seconds since 2000-01-01T00:00Z)\n"
04744             "# $10 = Col: view point altitude [km]\n"
04745             "# $11 = Col: view point longitude [deg]\n"
04746             "# $12 = Col: view point latitude [deg]\n");
04747
04748     /* Get number of columns... */
04749     nc = obs2y(ctl, obs, NULL, cida, cira);
04750
04751   } else {
04752
04753     fprintf(out,
04754             "# $7 = Col: index (state space)\n"
04755             "# $8 = Col: name of quantity\n"
04756             "# $9 = Col: time (seconds since 2000-01-01T00:00Z)\n"
04757             "# $10 = Col: altitude [km]\n"
04758             "# $11 = Col: longitude [deg]\n" "# $12 = Col: latitude [deg]\n");
04759
04760     /* Get number of columns... */
04761     nc = atm2x(ctl, atm, NULL, ciqa, cipa);
04762   }
04763
04764   /* Write header entry... */
04765   fprintf(out, "# $13 = Matrix element\n\n");
04766
04767   /* Write matrix data... */
04768   i = j = 0;
04769   while (i < nr && j < nc) {
04770
04771     /* Write info about the row... */
04772     if (rowspace[0] == 'y')
04773       fprintf(out, "%d %g %.2f %g %g %g",
04774               (int) i, ctl->nu[rida[i]],
04775               obs->time[rira[i]], obs->vpz[rira[i]],
04776               obs->vplon[rira[i]], obs->vplat[rira[i]]);
04777     else {
04778       idx2name(ctl, riqa[i], quantity);
04779       fprintf(out, "%d %s %.2f %g %g %g", (int) i, quantity,
04780               atm->time[ripa[i]], atm->z[ripa[i]],
04781               atm->lon[ripa[i]], atm->lat[ripa[i]]);
04782     }
04783
04784     /* Write info about the column... */
04785     if (colspace[0] == 'y')
04786       fprintf(out, " %d %g %.2f %g %g %g",
04787               (int) j, ctl->nu[cida[j]],
04788               obs->time[cira[j]], obs->vpz[cira[j]],
04789               obs->vplon[cira[j]], obs->vplat[cira[j]]);
04790     else {
04791       idx2name(ctl, ciqa[j], quantity);
04792       fprintf(out, " %d %s %.2f %g %g %g", (int) j, quantity,
04793               atm->time[cipa[j]], atm->z[cipa[j]],
04794               atm->lon[cipa[j]], atm->lat[cipa[j]]);
04795     }
04796
04797     /* Write matrix entry... */
04798     fprintf(out, " %g\n", gsl_matrix_get(matrix, i, j));
04799
04800     /* Set matrix indices... */
04801     if (sort[0] == 'r') {
04802       j++;
04803       if (j >= nc) {
04804         j = 0;
04805         i++;
04806         fprintf(out, "\n");
04807       }
04808     } else {
04809       i++;
04810       if (i >= nr) {
04811         i = 0;
04812         j++;
04813         fprintf(out, "\n");
04814       }
04815     }
04816   }
```

```
04817
04818   /* Close file... */
04819   fclose(out);
04820
04821   /* Free... */
04822   free(cida);
04823   free(ciqa);
04824   free(cipa);
04825   free(cira);
04826   free(rida);
04827   free(riqa);
04828   free(ripa);
04829   free(rira);
04830 }
04831
04832 /*****************************************************************************/
04833
04834 void write_obs(
04835   const char *dirname,
04836   const char *filename,
04837   ctl_t * ctl,
04838   obs_t * obs) {
04839
04840   FILE *out;
04841
04842   char file[LEN];
04843
04844   int id, ir, n = 10;
04845
04846   /* Set filename... */
04847   if (dirname != NULL)
04848     sprintf(file, "%s/%s", dirname, filename);
04849   else
04850     sprintf(file, "%s", filename);
04851
04852   /* Write info... */
04853   printf("Write observation data: %s\n", file);
04854
04855   /* Create file... */
04856   if (!(out = fopen(file, "w")))
04857     ERRMSG("Cannot create file!");
04858
04859   /* Write header... */
04860   fprintf(out,
04861           "# $1 = time (seconds since 2000-01-01T00:00Z)\n"
04862           "# $2 = observer altitude [km]\n"
04863           "# $3 = observer longitude [deg]\n"
04864           "# $4 = observer latitude [deg]\n"
04865           "# $5 = view point altitude [km]\n"
04866           "# $6 = view point longitude [deg]\n"
04867           "# $7 = view point latitude [deg]\n"
04868           "# $8 = tangent point altitude [km]\n"
04869           "# $9 = tangent point longitude [deg]\n"
04870           "# $10 = tangent point latitude [deg]\n");
04871   for (id = 0; id < ctl->nd; id++)
04872     fprintf(out, "# $%d = channel %g: radiance [W/(m^2 sr cm^-1)]\n",
04873             ++n, ctl->nu[id]);
04874   for (id = 0; id < ctl->nd; id++)
04875     fprintf(out, "# $%d = channel %g: transmittance\n", ++n, ctl->nu[id]);
04876
04877   /* Write data... */
04878   for (ir = 0; ir < obs->nr; ir++) {
04879     if (ir == 0 || obs->time[ir] != obs->time[ir - 1])
04880       fprintf(out, "\n");
04881     fprintf(out, "%.2f %g %g %g %g %g %g %g %g", obs->time[ir],
04882             obs->obsz[ir], obs->obslon[ir], obs->obslat[ir],
04883             obs->vpz[ir], obs->vplon[ir], obs->vplat[ir],
04884             obs->tpz[ir], obs->tplon[ir], obs->tplat[ir]);
04885     for (id = 0; id < ctl->nd; id++)
04886       fprintf(out, " %g", obs->rad[id][ir]);
04887     for (id = 0; id < ctl->nd; id++)
04888       fprintf(out, " %g", obs->tau[id][ir]);
04889     fprintf(out, "\n");
04890   }
04891
04892   /* Close file... */
04893   fclose(out);
04894 }
04895
04896 /*****************************************************************************/
04897
04898 void x2atm(
04899   ctl_t * ctl,
04900   gsl_vector * x,
04901   atm_t * atm) {
04902
04903   int ig, iw;
```

```
04904
04905   size_t n = 0;
04906
04907   /* Set pressure... */
04908   x2atm_help(atm, ctl->retp_zmin, ctl->retp_zmax, atm->
      p, x, &n);
04909
04910   /* Set temperature... */
04911   x2atm_help(atm, ctl->rett_zmin, ctl->rett_zmax, atm->
      t, x, &n);
04912
04913   /* Set volume mixing ratio... */
04914   for (ig = 0; ig < ctl->ng; ig++)
04915     x2atm_help(atm, ctl->retq_zmin[ig], ctl->retq_zmax[ig],
04916                atm->q[ig], x, &n);
04917
04918   /* Set extinction... */
04919   for (iw = 0; iw < ctl->nw; iw++)
04920     x2atm_help(atm, ctl->retk_zmin[iw], ctl->retk_zmax[iw],
04921                atm->k[iw], x, &n);
04922 }
04923
04924 /*****************************************************************************/
04925
04926 void x2atm_help(
04927   atm_t * atm,
04928   double zmin,
04929   double zmax,
04930   double *value,
04931   gsl_vector * x,
04932   size_t * n) {
04933
04934   int ip;
04935
04936   /* Extract state vector elements... */
04937   for (ip = 0; ip < atm->np; ip++)
04938     if (atm->z[ip] >= zmin && atm->z[ip] <= zmax) {
04939       value[ip] = gsl_vector_get(x, *n);
04940       (*n)++;
04941     }
04942 }
04943
04944 /*****************************************************************************/
04945
04946 void y2obs(
04947   ctl_t * ctl,
04948   gsl_vector * y,
04949   obs_t * obs) {
04950
04951   int id, ir;
04952
04953   size_t m = 0;
04954
04955   /* Decompose measurement vector... */
04956   for (ir = 0; ir < obs->nr; ir++)
04957     for (id = 0; id < ctl->nd; id++)
04958       if (gsl_finite(obs->rad[id][ir])) {
04959         obs->rad[id][ir] = gsl_vector_get(y, m);
04960         m++;
04961       }
04962 }
```

5.15 jurassic.h File Reference

JURASSIC library declarations.

Data Structures

- struct atm_t

  Atmospheric data.
- struct ctl_t

  Forward model control parameters.
- struct los_t

  Line-of-sight data.

- struct obs_t

  Observation geometry and radiance data.
- struct tbl_t

  Emissivity look-up tables.

Functions

- size_t atm2x (ctl_t *ctl, atm_t *atm, gsl_vector *x, int *iqa, int *ipa)

  Compose state vector or parameter vector.
- void atm2x_help (atm_t *atm, double zmin, double zmax, double *value, int val_iqa, gsl_vector *x, int *iqa, int *ipa, size_t *n)

  Add elements to state vector.
- double brightness (double rad, double nu)

  Compute brightness temperature.
- void cart2geo (double *x, double *z, double *lon, double *lat)

  Convert Cartesian coordinates to geolocation.
- void climatology (ctl_t *ctl, atm_t *atm_mean)

  Interpolate climatological data.
- double ctmco2 (double nu, double p, double t, double u)

  Compute carbon dioxide continuum (optical depth).
- double ctmh2o (double nu, double p, double t, double q, double u)

  Compute water vapor continuum (optical depth).
- double ctmn2 (double nu, double p, double t)

  Compute nitrogen continuum (absorption coefficient).
- double ctmo2 (double nu, double p, double t)

  Compute oxygen continuum (absorption coefficient).
- void copy_atm (ctl_t *ctl, atm_t *atm_dest, atm_t *atm_src, int init)

  Copy and initialize atmospheric data.
- void copy_obs (ctl_t *ctl, obs_t *obs_dest, obs_t *obs_src, int init)

  Copy and initialize observation data.
- int find_emitter (ctl_t *ctl, const char *emitter)

  Find index of an emitter.
- void formod (ctl_t *ctl, atm_t *atm, obs_t *obs)

  Determine ray paths and compute radiative transfer.
- void formod_continua (ctl_t *ctl, los_t *los, int ip, double *beta)

  Compute absorption coefficient of continua.
- void formod_fov (ctl_t *ctl, obs_t *obs)

  Apply field of view convolution.
- void formod_pencil (ctl_t *ctl, atm_t *atm, obs_t *obs, int ir)

  Compute radiative transfer for a pencil beam.
- void formod_srcfunc (ctl_t *ctl, tbl_t *tbl, double t, double *src)

  Compute Planck source function.
- void geo2cart (double z, double lon, double lat, double *x)

  Convert geolocation to Cartesian coordinates.
- void hydrostatic (ctl_t *ctl, atm_t *atm)

  Set hydrostatic equilibrium.
- void idx2name (ctl_t *ctl, int idx, char *quantity)

  Determine name of state vector quantity for given index.
- void init_tbl (ctl_t *ctl, tbl_t *tbl)

  Initialize look-up tables.

- void intpol_atm (ctl_t *ctl, atm_t *atm, double z, double *p, double *t, double *q, double *k)

  Interpolate atmospheric data.
- void intpol_tbl (ctl_t *ctl, tbl_t *tbl, los_t *los, int ip, double tau_path[NG][ND], double tau_seg[ND])

  Get transmittance from look-up tables.
- double intpol_tbl_eps (tbl_t *tbl, int ig, int id, int ip, int it, double u)

  Interpolate emissivity from look-up tables.
- double intpol_tbl_u (tbl_t *tbl, int ig, int id, int ip, int it, double eps)

  Interpolate column density from look-up tables.
- void jsec2time (double jsec, int *year, int *mon, int *day, int *hour, int *min, int *sec, double *remain)

  Convert seconds to date.
- void kernel (ctl_t *ctl, atm_t *atm, obs_t *obs, gsl_matrix *k)

  Compute Jacobians.
- int locate_irr (double *xx, int n, double x)

  Find array index for irregular grid.
- int locate_reg (double *xx, int n, double x)

  Find array index for regular grid.
- int locate_tbl (float *xx, int n, double x)

  Find array index in float array.
- size_t obs2y (ctl_t *ctl, obs_t *obs, gsl_vector *y, int *ida, int *ira)

  Compose measurement vector.
- double planck (double t, double nu)

  Compute Planck function.
- void raytrace (ctl_t *ctl, atm_t *atm, obs_t *obs, los_t *los, int ir)

  Do ray-tracing to determine LOS.
- void read_atm (const char *dirname, const char *filename, ctl_t *ctl, atm_t *atm)

  Read atmospheric data.
- void read_ctl (int argc, char *argv[ ], ctl_t *ctl)

  Read forward model control parameters.
- void read_matrix (const char *dirname, const char *filename, gsl_matrix *matrix)

  Read matrix.
- void read_obs (const char *dirname, const char *filename, ctl_t *ctl, obs_t *obs)

  Read observation data.
- void read_shape (const char *filename, double *x, double *y, int *n)

  Read shape function.
- double refractivity (double p, double t)

  Compute refractivity (return value is n - 1).
- double scan_ctl (int argc, char *argv[ ], const char *varname, int arridx, const char *defvalue, char *value)

  Search control parameter file for variable entry.
- void tangent_point (los_t *los, double *tpz, double *tplon, double *tplat)

  Find tangent point of a given LOS.
- void time2jsec (int year, int mon, int day, int hour, int min, int sec, double remain, double *jsec)

  Convert date to seconds.
- void timer (const char *name, const char *file, const char *func, int line, int mode)

  Measure wall-clock time.
- void write_atm (const char *dirname, const char *filename, ctl_t *ctl, atm_t *atm)

  Write atmospheric data.
- void write_matrix (const char *dirname, const char *filename, ctl_t *ctl, gsl_matrix *matrix, atm_t *atm, obs_t *obs, const char *rowspace, const char *colspace, const char *sort)

  Write matrix.
- void write_obs (const char *dirname, const char *filename, ctl_t *ctl, obs_t *obs)

  Write observation data.

- void x2atm (ctl_t *ctl, gsl_vector *x, atm_t *atm)

  Decompose parameter vector or state vector.
- void x2atm_help (atm_t *atm, double zmin, double zmax, double *value, gsl_vector *x, size_t *n)

  Extract elements from state vector.
- void y2obs (ctl_t *ctl, gsl_vector *y, obs_t *obs)

  Decompose measurement vector.

5.15.1 Detailed Description

JURASSIC library declarations.

Definition in file jurassic.h.

5.15.2 Function Documentation

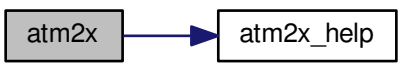
5.15.2.1 size_t atm2x (ctl_t * *ctl*, atm_t * *atm*, gsl_vector * *x*, int * *iqa*, int * *ipa*)

Compose state vector or parameter vector.

Definition at line 29 of file jurassic.c.

```
00034            {
00035
00036   int ig, iw;
00037
00038   size_t n = 0;
00039
00040   /* Add pressure... */
00041   atm2x_help(atm, ctl->retp_zmin, ctl->retp_zmax,
00042              atm->p, IDXP, x, iqa, ipa, &n);
00043
00044   /* Add temperature... */
00045   atm2x_help(atm, ctl->rett_zmin, ctl->rett_zmax,
00046              atm->t, IDXT, x, iqa, ipa, &n);
00047
00048   /* Add volume mixing ratios... */
00049   for (ig = 0; ig < ctl->ng; ig++)
00050     atm2x_help(atm, ctl->retq_zmin[ig], ctl->retq_zmax[ig],
00051                atm->q[ig], IDXQ(ig), x, iqa, ipa, &n);
00052
00053   /* Add extinction... */
00054   for (iw = 0; iw < ctl->nw; iw++)
00055     atm2x_help(atm, ctl->retk_zmin[iw], ctl->retk_zmax[iw],
00056                atm->k[iw], IDXK(iw), x, iqa, ipa, &n);
00057
00058   return n;
00059 }
```

Here is the call graph for this function:



5.15.2.2 void atm2x_help (atm_t * *atm*, double *zmin*, double *zmax*, double * *value*, int *val_iqa*, gsl_vector * *x*, int * *iqa*, int * *ipa*, size_t * *n*)

Add elements to state vector.

Definition at line 63 of file jurassic.c.

```
00072               {
00073
00074   int ip;
00075
00076   /* Add elements to state vector... */
00077   for (ip = 0; ip < atm->np; ip++)
00078     if (atm->z[ip] >= zmin && atm->z[ip] <= zmax) {
00079       if (x != NULL)
00080         gsl_vector_set(x, *n, value[ip]);
00081       if (iqa != NULL)
00082         iqa[*n] = val_iqa;
00083       if (ipa != NULL)
00084         ipa[*n] = ip;
00085       (*n)++;
00086     }
00087 }
```

5.15.2.3 double brightness (double *rad*, double *nu*)

Compute brightness temperature.

Definition at line 91 of file jurassic.c.

```
00093               {
00094
00095   return C2 * nu / gsl_log1p(C1 * POW3(nu) / rad);
00096 }
```

5.15.2.4 void cart2geo (double * *x*, double * *z*, double * *lon*, double * *lat*)

Convert Cartesian coordinates to geolocation.

Definition at line 101 of file jurassic.c.

```
00105                {
00106
00107   double radius;
00108
00109   radius = NORM(x);
00110   *lat = asin(x[2] / radius) * 180 / M_PI;
00111   *lon = atan2(x[1], x[0]) * 180 / M_PI;
00112   *z = radius - RE;
00113 }
```

5.15.2.5 void climatology (ctl_t * *ctl*, atm_t * *atm_mean*)

Interpolate climatological data.

Definition at line 117 of file jurassic.c.

```
00119               {
00120
00121   static double z[121] = {
00122     0, 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11, 12, 13, 14, 15, 16, 17, 18, 19,
00123     20, 21, 22, 23, 24, 25, 26, 27, 28, 29, 30, 31, 32, 33, 34, 35, 36, 37,
00124     38, 39, 40, 41, 42, 43, 44, 45, 46, 47, 48, 49, 50, 51, 52, 53, 54, 55,
00125     56, 57, 58, 59, 60, 61, 62, 63, 64, 65, 66, 67, 68, 69, 70, 71, 72, 73,
00126     74, 75, 76, 77, 78, 79, 80, 81, 82, 83, 84, 85, 86, 87, 88, 89, 90, 91,
00127     92, 93, 94, 95, 96, 97, 98, 99, 100, 101, 102, 103, 104, 105, 106, 107,
00128     108, 109, 110, 111, 112, 113, 114, 115, 116, 117, 118, 119, 120
00129   };
00130
00131   static double pre[121] = {
00132     1017, 901.083, 796.45, 702.227, 617.614, 541.644, 473.437, 412.288,
00133     357.603, 308.96, 265.994, 228.348, 195.619, 167.351, 143.039, 122.198,
00134     104.369, 89.141, 76.1528, 65.0804, 55.641, 47.591, 40.7233, 34.8637,
00135     29.8633, 25.5956, 21.9534, 18.8445, 16.1909, 13.9258, 11.9913,
00136     10.34, 8.92988, 7.72454, 6.6924, 5.80701, 5.04654, 4.39238, 3.82902,
00137     3.34337, 2.92413, 2.56128, 2.2464, 1.97258, 1.73384, 1.52519, 1.34242,
00138     1.18197, 1.04086, 0.916546, 0.806832, 0.709875, 0.624101, 0.548176,
00139     0.480974, 0.421507, 0.368904, 0.322408, 0.281386, 0.245249, 0.213465,
00140     0.185549, 0.161072, 0.139644, 0.120913, 0.104568, 0.0903249, 0.0779269,
00141     0.0671493, 0.0577962, 0.0496902, 0.0426736, 0.0366093, 0.0313743,
00142     0.0268598, 0.0229699, 0.0196206, 0.0167399, 0.0142646, 0.0121397,
00143     0.0103181, 0.00875775, 0.00742226, 0.00628076, 0.00530519, 0.00447183,
00144     0.00376124, 0.00315632, 0.00264248, 0.00220738, 0.00184003, 0.00153095,
00145     0.00127204, 0.00105608, 0.000876652, 0.00072798, 0.00060492,
00146     0.000503201, 0.000419226, 0.000349896, 0.000292659, 0.000245421,
00147     0.000206394, 0.000174125, 0.000147441, 0.000125333, 0.000106985,
00148     9.173e-05, 7.90172e-05, 6.84172e-05, 5.95574e-05, 5.21183e-05,
00149     4.58348e-05, 4.05127e-05, 3.59987e-05, 3.21583e-05, 2.88718e-05,
00150     2.60322e-05, 2.35687e-05, 2.14263e-05, 1.95489e-05
00151   };
00152
00153   static double tem[121] = {
00154     285.14, 279.34, 273.91, 268.3, 263.24, 256.55, 250.2, 242.82, 236.17,
00155     229.87, 225.04, 221.19, 218.85, 217.19, 216.2, 215.68, 215.42, 215.55,
00156     215.92, 216.4, 216.93, 217.45, 218, 218.68, 219.39, 220.25, 221.3,
00157     222.41, 223.88, 225.42, 227.2, 229.52, 231.89, 234.51, 236.85, 239.42,
00158     241.94, 244.57, 247.36, 250.32, 253.34, 255.82, 258.27, 260.39,
00159     262.03, 263.45, 264.2, 264.78, 264.67, 264.38, 263.24, 262.03, 260.02,
00160     258.09, 255.63, 253.28, 250.43, 247.81, 245.26, 242.77, 240.38,
00161     237.94, 235.79, 233.53, 231.5, 229.53, 227.6, 225.62, 223.77, 222.06,
00162     220.33, 218.69, 217.18, 215.64, 214.13, 212.52, 210.86, 209.25,
00163     207.49, 205.81, 204.11, 202.22, 200.32, 198.39, 195.92, 193.46,
00164     190.94, 188.31, 185.82, 183.57, 181.43, 179.74, 178.64, 178.1, 178.25,
00165     178.7, 179.41, 180.67, 182.31, 184.18, 186.6, 189.53, 192.66, 196.54,
00166     201.13, 205.93, 211.73, 217.86, 225, 233.53, 242.57, 252.14, 261.48,
00167     272.97, 285.26, 299.12, 312.2, 324.17, 338.34, 352.56, 365.28
00168   };
00169
00170   static double c2h2[121] = {
00171     1.352e-09, 2.83e-10, 1.269e-10, 6.926e-11, 4.346e-11, 2.909e-11,
00172     2.014e-11, 1.363e-11, 8.71e-12, 5.237e-12, 2.718e-12, 1.375e-12,
00173     5.786e-13, 2.16e-13, 7.317e-14, 2.551e-14, 1.055e-14, 4.758e-15,
00174     2.056e-15, 7.703e-16, 2.82e-16, 1.035e-16, 4.382e-17, 1.946e-17,
00175     9.638e-18, 5.2e-18, 2.811e-18, 1.494e-18, 7.925e-19, 4.213e-19,
00176     1.998e-19, 8.78e-20, 3.877e-20, 1.728e-20, 7.743e-21, 3.536e-21,
00177     1.623e-21, 7.508e-22, 3.508e-22, 1.65e-22, 7.837e-23, 3.733e-23,
00178     1.808e-23, 8.77e-24, 4.285e-24, 2.095e-24, 1.032e-24, 5.082e-25,
00179     2.506e-25, 1.236e-25, 6.088e-26, 2.996e-26, 1.465e-26, 0, 0, 0,
00180     0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
00181     0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
00182     0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0
00183   };
00184
00185   static double c2h6[121] = {
00186     2.667e-09, 2.02e-09, 1.658e-09, 1.404e-09, 1.234e-09, 1.109e-09,
00187     1.012e-09, 9.262e-10, 8.472e-10, 7.71e-10, 6.932e-10, 6.216e-10,
00188     5.503e-10, 4.87e-10, 4.342e-10, 3.861e-10, 3.347e-10, 2.772e-10,
00189     2.209e-10, 1.672e-10, 1.197e-10, 8.536e-11, 5.783e-11, 3.846e-11,
00190     2.495e-11, 1.592e-11, 1.017e-11, 6.327e-12, 3.895e-12, 2.403e-12,
00191     1.416e-12, 8.101e-13, 4.649e-13, 2.686e-13, 1.557e-13, 9.14e-14,
00192     5.386e-14, 3.19e-14, 1.903e-14, 1.14e-14, 6.875e-15, 4.154e-15,
00193     2.538e-15, 1.553e-15, 9.548e-16, 5.872e-16, 3.63e-16, 2.244e-16,
00194     1.388e-16, 8.587e-17, 5.308e-17, 3.279e-17, 2.017e-17, 1.238e-17,
00195     7.542e-18, 4.585e-18, 2.776e-18, 1.671e-18, 9.985e-19, 5.937e-19,
```

```
00196     3.518e-19, 2.07e-19, 1.215e-19, 7.06e-20, 4.097e-20, 2.37e-20,
00197     1.363e-20, 7.802e-21, 4.441e-21, 2.523e-21, 1.424e-21, 8.015e-22,
00198     4.497e-22, 2.505e-22, 1.391e-22, 7.691e-23, 4.238e-23, 2.331e-23,
00199     1.274e-23, 6.929e-24, 3.752e-24, 2.02e-24, 1.083e-24, 5.774e-25,
00200     3.041e-25, 1.593e-25, 8.308e-26, 4.299e-26, 2.195e-26, 1.112e-26,
00201     0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0, 0,
00202     0, 0, 0, 0, 0, 0, 0, 0, 0
00203   };
00204
00205   static double ccl4[121] = {
00206     1.075e-10, 1.075e-10, 1.075e-10, 1.075e-10, 1.075e-10, 1.075e-10,
00207     1.075e-10, 1.075e-10, 1.075e-10, 1.06e-10, 1.024e-10, 9.69e-11,
00208     8.93e-11, 8.078e-11, 7.213e-11, 6.307e-11, 5.383e-11, 4.49e-11,
00209     3.609e-11, 2.705e-11, 1.935e-11, 1.385e-11, 8.35e-12, 5.485e-12,
00210     3.853e-12, 2.22e-12, 5.875e-13, 3.445e-13, 1.015e-13, 6.075e-14,
00211     4.383e-14, 2.692e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14,
00212     1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14,
00213     1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14,
00214     1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14,
00215     1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14,
00216     1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14,
00217     1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14,
00218     1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14,
00219     1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14, 1e-14,
00220     1e-14, 1e-14, 1e-14
00221   };
00222
00223   static double ch4[121] = {
00224     1.864e-06, 1.835e-06, 1.819e-06, 1.805e-06, 1.796e-06, 1.788e-06,
00225     1.782e-06, 1.776e-06, 1.769e-06, 1.761e-06, 1.749e-06, 1.734e-06,
00226     1.716e-06, 1.692e-06, 1.654e-06, 1.61e-06, 1.567e-06, 1.502e-06,
00227     1.433e-06, 1.371e-06, 1.323e-06, 1.277e-06, 1.232e-06, 1.188e-06,
00228     1.147e-06, 1.108e-06, 1.07e-06, 1.027e-06, 9.854e-07, 9.416e-07,
00229     8.933e-07, 8.478e-07, 7.988e-07, 7.515e-07, 7.07e-07, 6.64e-07,
00230     6.239e-07, 5.864e-07, 5.512e-07, 5.184e-07, 4.87e-07, 4.571e-07,
00231     4.296e-07, 4.04e-07, 3.802e-07, 3.578e-07, 3.383e-07, 3.203e-07,
00232     3.032e-07, 2.889e-07, 2.76e-07, 2.635e-07, 2.519e-07, 2.409e-07,
00233     2.302e-07, 2.219e-07, 2.144e-07, 2.071e-07, 1.999e-07, 1.93e-07,
00234     1.862e-07, 1.795e-07, 1.731e-07, 1.668e-07, 1.607e-07, 1.548e-07,
00235     1.49e-07, 1.434e-07, 1.38e-07, 1.328e-07, 1.277e-07, 1.227e-07,
00236     1.18e-07, 1.134e-07, 1.089e-07, 1.046e-07, 1.004e-07, 9.635e-08,
00237     9.245e-08, 8.867e-08, 8.502e-08, 8.15e-08, 7.809e-08, 7.48e-08,
00238     7.159e-08, 6.849e-08, 6.55e-08, 6.262e-08, 5.98e-08, 5.708e-08,
00239     5.448e-08, 5.194e-08, 4.951e-08, 4.72e-08, 4.5e-08, 4.291e-08,
00240     4.093e-08, 3.905e-08, 3.729e-08, 3.563e-08, 3.408e-08, 3.265e-08,
00241     3.128e-08, 2.996e-08, 2.87e-08, 2.76e-08, 2.657e-08, 2.558e-08,
00242     2.467e-08, 2.385e-08, 2.307e-08, 2.234e-08, 2.168e-08, 2.108e-08,
00243     2.05e-08, 1.998e-08, 1.947e-08, 1.902e-08, 1.86e-08, 1.819e-08,
00244     1.782e-08
00245   };
00246
00247   static double clo[121] = {
00248     7.419e-15, 1.061e-14, 1.518e-14, 2.195e-14, 3.175e-14, 4.666e-14,
00249     6.872e-14, 1.03e-13, 1.553e-13, 2.375e-13, 3.664e-13, 5.684e-13,
00250     8.915e-13, 1.402e-12, 2.269e-12, 4.125e-12, 7.501e-12, 1.257e-11,
00251     2.048e-11, 3.338e-11, 5.44e-11, 8.846e-11, 1.008e-10, 1.082e-10,
00252     1.157e-10, 1.232e-10, 1.312e-10, 1.539e-10, 1.822e-10, 2.118e-10,
00253     2.387e-10, 2.687e-10, 2.875e-10, 3.031e-10, 3.23e-10, 3.648e-10,
00254     4.117e-10, 4.477e-10, 4.633e-10, 4.794e-10, 4.95e-10, 5.104e-10,
00255     5.259e-10, 5.062e-10, 4.742e-10, 4.443e-10, 4.051e-10, 3.659e-10,
00256     3.305e-10, 2.911e-10, 2.54e-10, 2.215e-10, 1.927e-10, 1.675e-10,
00257     1.452e-10, 1.259e-10, 1.09e-10, 9.416e-11, 8.119e-11, 6.991e-11,
00258     6.015e-11, 5.163e-11, 4.43e-11, 3.789e-11, 3.24e-11, 2.769e-11,
00259     2.361e-11, 2.011e-11, 1.71e-11, 1.453e-11, 1.233e-11, 1.045e-11,
00260     8.851e-12, 7.48e-12, 6.316e-12, 5.326e-12, 4.487e-12, 3.778e-12,
00261     3.176e-12, 2.665e-12, 2.234e-12, 1.87e-12, 1.563e-12, 1.304e-12,
00262     1.085e-12, 9.007e-13, 7.468e-13, 6.179e-13, 5.092e-13, 4.188e-13,
00263     3.442e-13, 2.816e-13, 2.304e-13, 1.885e-13, 1.542e-13, 1.263e-13,
00264     1.035e-13, 8.5e-14, 7.004e-14, 5.783e-14, 4.795e-14, 4.007e-14,
00265     3.345e-14, 2.792e-14, 2.33e-14, 1.978e-14, 1.686e-14, 1.438e-14,
00266     1.234e-14, 1.07e-14, 9.312e-15, 8.131e-15, 7.164e-15, 6.367e-15,
00267     5.67e-15, 5.088e-15, 4.565e-15, 4.138e-15, 3.769e-15, 3.432e-15,
00268     3.148e-15
00269   };
00270
00271   static double clono2[121] = {
00272     1.011e-13, 1.515e-13, 2.272e-13, 3.446e-13, 5.231e-13, 8.085e-13,
00273     1.253e-12, 1.979e-12, 3.149e-12, 5.092e-12, 8.312e-12, 1.366e-11,
00274     2.272e-11, 3.791e-11, 6.209e-11, 9.101e-11, 1.334e-10, 1.951e-10,
00275     2.853e-10, 3.94e-10, 4.771e-10, 5.771e-10, 6.675e-10, 7.665e-10,
00276     8.504e-10, 8.924e-10, 9.363e-10, 8.923e-10, 8.411e-10, 7.646e-10,
00277     6.525e-10, 5.576e-10, 4.398e-10, 3.403e-10, 2.612e-10, 1.915e-10,
00278     1.407e-10, 1.028e-10, 7.455e-11, 5.42e-11, 3.708e-11, 2.438e-11,
00279     1.618e-11, 1.075e-11, 7.17e-12, 4.784e-12, 3.205e-12, 2.147e-12,
00280     1.44e-12, 9.654e-13, 6.469e-13, 4.332e-13, 2.891e-13, 1.926e-13,
00281     1.274e-13, 8.422e-14, 5.547e-14, 3.636e-14, 2.368e-14, 1.536e-14,
00282     9.937e-15, 6.39e-15, 4.101e-15, 2.61e-15, 1.659e-15, 1.052e-15,
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00283     6.638e-16, 4.172e-16, 2.61e-16, 1.63e-16, 1.013e-16, 6.275e-17,
00284     3.879e-17, 2.383e-17, 1.461e-17, 8.918e-18, 5.43e-18, 3.301e-18,
00285     1.997e-18, 1.203e-18, 7.216e-19, 4.311e-19, 2.564e-19, 1.519e-19,
00286     8.911e-20, 5.203e-20, 3.026e-20, 1.748e-20, 9.99e-21, 5.673e-21,
00287     3.215e-21, 1.799e-21, 1.006e-21, 5.628e-22, 3.146e-22, 1.766e-22,
00288     9.94e-23, 5.614e-23, 3.206e-23, 1.841e-23, 1.071e-23, 6.366e-24,
00289     3.776e-24, 2.238e-24, 1.326e-24, 8.253e-25, 5.201e-25, 3.279e-25,
00290     2.108e-25, 1.395e-25, 9.326e-26, 6.299e-26, 4.365e-26, 3.104e-26,
00291     2.219e-26, 1.621e-26, 1.185e-26, 8.92e-27, 6.804e-27, 5.191e-27,
00292     4.041e-27
00293   };
00294
00295   static double co[121] = {
00296     1.907e-07, 1.553e-07, 1.362e-07, 1.216e-07, 1.114e-07, 1.036e-07,
00297     9.737e-08, 9.152e-08, 8.559e-08, 7.966e-08, 7.277e-08, 6.615e-08,
00298     5.884e-08, 5.22e-08, 4.699e-08, 4.284e-08, 3.776e-08, 3.274e-08,
00299     2.845e-08, 2.479e-08, 2.246e-08, 2.054e-08, 1.991e-08, 1.951e-08,
00300     1.94e-08, 2.009e-08, 2.1e-08, 2.201e-08, 2.322e-08, 2.45e-08,
00301     2.602e-08, 2.73e-08, 2.867e-08, 2.998e-08, 3.135e-08, 3.255e-08,
00302     3.352e-08, 3.426e-08, 3.484e-08, 3.53e-08, 3.593e-08, 3.671e-08,
00303     3.759e-08, 3.945e-08, 4.192e-08, 4.49e-08, 5.03e-08, 5.703e-08,
00304     6.538e-08, 7.878e-08, 9.644e-08, 1.196e-07, 1.498e-07, 1.904e-07,
00305     2.422e-07, 3.055e-07, 3.804e-07, 4.747e-07, 5.899e-07, 7.272e-07,
00306     8.91e-07, 1.071e-06, 1.296e-06, 1.546e-06, 1.823e-06, 2.135e-06,
00307     2.44e-06, 2.714e-06, 2.967e-06, 3.189e-06, 3.391e-06, 3.58e-06,
00308     3.773e-06, 4.022e-06, 4.346e-06, 4.749e-06, 5.199e-06, 5.668e-06,
00309     6.157e-06, 6.688e-06, 7.254e-06, 7.867e-06, 8.539e-06, 9.26e-06,
00310     1.009e-05, 1.119e-05, 1.228e-05, 1.365e-05, 1.506e-05, 1.641e-05,
00311     1.784e-05, 1.952e-05, 2.132e-05, 2.323e-05, 2.531e-05, 2.754e-05,
00312     3.047e-05, 3.459e-05, 3.922e-05, 4.439e-05, 4.825e-05, 5.077e-05,
00313     5.34e-05, 5.618e-05, 5.909e-05, 6.207e-05, 6.519e-05, 6.845e-05,
00314     6.819e-05, 6.726e-05, 6.622e-05, 6.512e-05, 6.671e-05, 6.862e-05,
00315     7.048e-05, 7.264e-05, 7.3e-05, 7.3e-05, 7.3e-05, 7.3e-05, 7.3e-05
00316   };
00317
00318   static double cof2[121] = {
00319     7.5e-14, 1.055e-13, 1.485e-13, 2.111e-13, 3.001e-13, 4.333e-13,
00320     6.269e-13, 9.221e-13, 1.364e-12, 2.046e-12, 3.093e-12, 4.703e-12,
00321     7.225e-12, 1.113e-11, 1.66e-11, 2.088e-11, 2.626e-11, 3.433e-11,
00322     4.549e-11, 5.886e-11, 7.21e-11, 8.824e-11, 1.015e-10, 1.155e-10,
00323     1.288e-10, 1.388e-10, 1.497e-10, 1.554e-10, 1.606e-10, 1.639e-10,
00324     1.64e-10, 1.64e-10, 1.596e-10, 1.542e-10, 1.482e-10, 1.382e-10,
00325     1.289e-10, 1.198e-10, 1.109e-10, 1.026e-10, 9.484e-11, 8.75e-11,
00326     8.086e-11, 7.49e-11, 6.948e-11, 6.446e-11, 5.961e-11, 5.505e-11,
00327     5.085e-11, 4.586e-11, 4.1e-11, 3.665e-11, 3.235e-11, 2.842e-11,
00328     2.491e-11, 2.11e-11, 1.769e-11, 1.479e-11, 1.197e-11, 9.631e-12,
00329     7.74e-12, 6.201e-12, 4.963e-12, 3.956e-12, 3.151e-12, 2.507e-12,
00330     1.99e-12, 1.576e-12, 1.245e-12, 9.83e-13, 7.742e-13, 6.088e-13,
00331     4.782e-13, 3.745e-13, 2.929e-13, 2.286e-13, 1.782e-13, 1.388e-13,
00332     1.079e-13, 8.362e-14, 6.471e-14, 4.996e-14, 3.85e-14, 2.96e-14,
00333     2.265e-14, 1.729e-14, 1.317e-14, 9.998e-15, 7.549e-15, 5.683e-15,
00334     4.273e-15, 3.193e-15, 2.385e-15, 1.782e-15, 1.331e-15, 9.957e-16,
00335     7.461e-16, 5.601e-16, 4.228e-16, 3.201e-16, 2.438e-16, 1.878e-16,
00336     1.445e-16, 1.111e-16, 8.544e-17, 6.734e-17, 5.341e-17, 4.237e-17,
00337     3.394e-17, 2.759e-17, 2.254e-17, 1.851e-17, 1.54e-17, 1.297e-17,
00338     1.096e-17, 9.365e-18, 8e-18, 6.938e-18, 6.056e-18, 5.287e-18,
00339     4.662e-18
00340   };
00341
00342   static double f11[121] = {
00343     2.65e-10, 2.65e-10, 2.65e-10, 2.65e-10, 2.65e-10, 2.65e-10, 2.65e-10,
00344     2.65e-10, 2.65e-10, 2.65e-10, 2.65e-10, 2.65e-10, 2.635e-10, 2.536e-10,
00345     2.44e-10, 2.348e-10, 2.258e-10, 2.153e-10, 2.046e-10, 1.929e-10,
00346     1.782e-10, 1.648e-10, 1.463e-10, 1.291e-10, 1.1e-10, 8.874e-11,
00347     7.165e-11, 5.201e-11, 3.744e-11, 2.577e-11, 1.64e-11, 1.048e-11,
00348     5.993e-12, 3.345e-12, 1.839e-12, 9.264e-13, 4.688e-13, 2.329e-13,
00349     1.129e-13, 5.505e-14, 2.825e-14, 1.492e-14, 7.997e-15, 5.384e-15,
00350     3.988e-15, 2.955e-15, 2.196e-15, 1.632e-15, 1.214e-15, 9.025e-16,
00351     6.708e-16, 4.984e-16, 3.693e-16, 2.733e-16, 2.013e-16, 1.481e-16,
00352     1.087e-16, 7.945e-17, 5.782e-17, 4.195e-17, 3.038e-17, 2.19e-17,
00353     1.577e-17, 1.128e-17, 8.063e-18, 5.753e-18, 4.09e-18, 2.899e-18,
00354     2.048e-18, 1.444e-18, 1.015e-18, 7.12e-19, 4.985e-19, 3.474e-19,
00355     2.417e-19, 1.677e-19, 1.161e-19, 8.029e-20, 5.533e-20, 3.799e-20,
00356     2.602e-20, 1.776e-20, 1.209e-20, 8.202e-21, 5.522e-21, 3.707e-21,
00357     2.48e-21, 1.652e-21, 1.091e-21, 7.174e-22, 4.709e-22, 3.063e-22,
00358     1.991e-22, 1.294e-22, 8.412e-23, 5.483e-23, 3.581e-23, 2.345e-23,
00359     1.548e-23, 1.027e-23, 6.869e-24, 4.673e-24, 3.173e-24, 2.153e-24,
00360     1.461e-24, 1.028e-24, 7.302e-25, 5.188e-25, 3.739e-25, 2.753e-25,
00361     2.043e-25, 1.528e-25, 1.164e-25, 9.041e-26, 7.051e-26, 5.587e-26,
00362     4.428e-26, 3.588e-26, 2.936e-26, 2.402e-26, 1.995e-26
00363   };
00364
00365   static double f12[121] = {
00366     5.45e-10, 5.45e-10, 5.45e-10, 5.45e-10, 5.45e-10, 5.45e-10, 5.45e-10,
00367     5.45e-10, 5.45e-10, 5.45e-10, 5.45e-10, 5.45e-10, 5.429e-10, 5.291e-10,
00368     5.155e-10, 5.022e-10, 4.893e-10, 4.772e-10, 4.655e-10, 4.497e-10,
00369     4.249e-10, 4.015e-10, 3.632e-10, 3.261e-10, 2.858e-10, 2.408e-10,
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00370     2.03e-10, 1.685e-10, 1.4e-10, 1.163e-10, 9.65e-11, 8.02e-11, 6.705e-11,
00371     5.624e-11, 4.764e-11, 4.249e-11, 3.792e-11, 3.315e-11, 2.819e-11,
00372     2.4e-11, 1.999e-11, 1.64e-11, 1.352e-11, 1.14e-11, 9.714e-12,
00373     8.28e-12, 7.176e-12, 6.251e-12, 5.446e-12, 4.72e-12, 4.081e-12,
00374     3.528e-12, 3.08e-12, 2.699e-12, 2.359e-12, 2.111e-12, 1.901e-12,
00375     1.709e-12, 1.534e-12, 1.376e-12, 1.233e-12, 1.103e-12, 9.869e-13,
00376     8.808e-13, 7.859e-13, 7.008e-13, 6.241e-13, 5.553e-13, 4.935e-13,
00377     4.383e-13, 3.889e-13, 3.447e-13, 3.054e-13, 2.702e-13, 2.389e-13,
00378     2.11e-13, 1.862e-13, 1.643e-13, 1.448e-13, 1.274e-13, 1.121e-13,
00379     9.844e-14, 8.638e-14, 7.572e-14, 6.62e-14, 5.782e-14, 5.045e-14,
00380     4.394e-14, 3.817e-14, 3.311e-14, 2.87e-14, 2.48e-14, 2.142e-14,
00381     1.851e-14, 1.599e-14, 1.383e-14, 1.196e-14, 1.036e-14, 9e-15,
00382     7.828e-15, 6.829e-15, 5.992e-15, 5.254e-15, 4.606e-15, 4.037e-15,
00383     3.583e-15, 3.19e-15, 2.841e-15, 2.542e-15, 2.291e-15, 2.07e-15,
00384     1.875e-15, 1.71e-15, 1.57e-15, 1.442e-15, 1.333e-15, 1.232e-15,
00385     1.147e-15, 1.071e-15, 1.001e-15, 9.396e-16
00386   };
00387
00388   static double f14[121] = {
00389     9e-11, 9e-11, 9e-11, 9e-11, 9e-11, 9e-11, 9e-11, 9e-11, 9e-11, 9e-11,
00390     9e-11, 9e-11, 9e-11, 9e-11, 9e-11, 8.91e-11, 8.73e-11, 8.46e-11,
00391     8.19e-11, 7.92e-11, 7.74e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00392     7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00393     7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00394     7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00395     7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00396     7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00397     7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00398     7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00399     7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00400     7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00401     7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00402     7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00403     7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00404     7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11,
00405     7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11, 7.65e-11
00406   };
00407
00408   static double f22[121] = {
00409     1.4e-10, 1.4e-10, 1.4e-10, 1.4e-10, 1.4e-10, 1.4e-10,
00410     1.4e-10, 1.4e-10, 1.4e-10, 1.372e-10, 1.317e-10, 1.235e-10, 1.153e-10,
00411     1.075e-10, 1.002e-10, 9.332e-11, 8.738e-11, 8.194e-11, 7.7e-11,
00412     7.165e-11, 6.753e-11, 6.341e-11, 5.971e-11, 5.6e-11, 5.229e-11,
00413     4.859e-11, 4.488e-11, 4.118e-11, 3.83e-11, 3.568e-11, 3.308e-11,
00414     3.047e-11, 2.82e-11, 2.594e-11, 2.409e-11, 2.237e-11, 2.065e-11,
00415     1.894e-11, 1.771e-11, 1.647e-11, 1.532e-11, 1.416e-11, 1.332e-11,
00416     1.246e-11, 1.161e-11, 1.087e-11, 1.017e-11, 9.471e-12, 8.853e-12,
00417     8.235e-12, 7.741e-12, 7.247e-12, 6.836e-12, 6.506e-12, 6.176e-12,
00418     5.913e-12, 5.65e-12, 5.419e-12, 5.221e-12, 5.024e-12, 4.859e-12,
00419     4.694e-12, 4.546e-12, 4.414e-12, 4.282e-12, 4.15e-12, 4.019e-12,
00420     3.903e-12, 3.805e-12, 3.706e-12, 3.607e-12, 3.508e-12, 3.41e-12,
00421     3.31e-12, 3.212e-12, 3.129e-12, 3.047e-12, 2.964e-12, 2.882e-12,
00422     2.8e-12, 2.734e-12, 2.668e-12, 2.602e-12, 2.537e-12, 2.471e-12,
00423     2.421e-12, 2.372e-12, 2.322e-12, 2.273e-12, 2.224e-12, 2.182e-12,
00424     2.141e-12, 2.1e-12, 2.059e-12, 2.018e-12, 1.977e-12, 1.935e-12,
00425     1.894e-12, 1.853e-12, 1.812e-12, 1.77e-12, 1.73e-12, 1.688e-12,
00426     1.647e-12, 1.606e-12, 1.565e-12, 1.524e-12, 1.483e-12, 1.441e-12,
00427     1.4e-12, 1.359e-12, 1.317e-12, 1.276e-12, 1.235e-12, 1.194e-12,
00428     1.153e-12, 1.112e-12, 1.071e-12, 1.029e-12, 9.883e-13
00429   };
00430
00431   static double h2o[121] = {
00432     0.01166, 0.008269, 0.005742, 0.003845, 0.00277, 0.001897, 0.001272,
00433     0.000827, 0.000539, 0.0003469, 0.0001579, 3.134e-05, 1.341e-05,
00434     6.764e-06, 4.498e-06, 3.703e-06, 3.724e-06, 3.899e-06, 4.002e-06,
00435     4.122e-06, 4.277e-06, 4.438e-06, 4.558e-06, 4.673e-06, 4.763e-06,
00436     4.809e-06, 4.856e-06, 4.936e-06, 5.021e-06, 5.114e-06, 5.222e-06,
00437     5.331e-06, 5.414e-06, 5.488e-06, 5.563e-06, 5.633e-06, 5.704e-06,
00438     5.767e-06, 5.819e-06, 5.872e-06, 5.914e-06, 5.949e-06, 5.984e-06,
00439     6.015e-06, 6.044e-06, 6.073e-06, 6.104e-06, 6.136e-06, 6.167e-06,
00440     6.189e-06, 6.208e-06, 6.226e-06, 6.212e-06, 6.185e-06, 6.158e-06,
00441     6.114e-06, 6.066e-06, 6.018e-06, 5.877e-06, 5.728e-06, 5.582e-06,
00442     5.437e-06, 5.296e-06, 5.156e-06, 5.02e-06, 4.886e-06, 4.754e-06,
00443     4.625e-06, 4.498e-06, 4.374e-06, 4.242e-06, 4.096e-06, 3.955e-06,
00444     3.817e-06, 3.683e-06, 3.491e-06, 3.204e-06, 2.94e-06, 2.696e-06,
00445     2.47e-06, 2.252e-06, 2.019e-06, 1.808e-06, 1.618e-06, 1.445e-06,
00446     1.285e-06, 1.105e-06, 9.489e-07, 8.121e-07, 6.938e-07, 5.924e-07,
00447     5.04e-07, 4.288e-07, 3.648e-07, 3.103e-07, 2.642e-07, 2.252e-07,
00448     1.921e-07, 1.643e-07, 1.408e-07, 1.211e-07, 1.048e-07, 9.063e-08,
00449     7.835e-08, 6.774e-08, 5.936e-08, 5.221e-08, 4.592e-08, 4.061e-08,
00450     3.62e-08, 3.236e-08, 2.902e-08, 2.62e-08, 2.383e-08, 2.171e-08,
00451     1.989e-08, 1.823e-08, 1.684e-08, 1.562e-08, 1.449e-08, 1.351e-08
00452   };
00453
00454   static double h2o2[121] = {
00455     1.779e-10, 7.938e-10, 8.953e-10, 8.032e-10, 6.564e-10, 5.159e-10,
00456     4.003e-10, 3.026e-10, 2.222e-10, 1.58e-10, 1.044e-10, 6.605e-11,
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00457     3.413e-11, 1.453e-11, 1.062e-11, 1.009e-11, 9.597e-12, 1.175e-11,
00458     1.572e-11, 2.091e-11, 2.746e-11, 3.603e-11, 4.791e-11, 6.387e-11,
00459     8.239e-11, 1.007e-10, 1.23e-10, 1.363e-10, 1.489e-10, 1.585e-10,
00460     1.608e-10, 1.632e-10, 1.576e-10, 1.502e-10, 1.423e-10, 1.302e-10,
00461     1.192e-10, 1.085e-10, 9.795e-11, 8.854e-11, 8.057e-11, 7.36e-11,
00462     6.736e-11, 6.362e-11, 6.087e-11, 5.825e-11, 5.623e-11, 5.443e-11,
00463     5.27e-11, 5.098e-11, 4.931e-11, 4.769e-11, 4.611e-11, 4.458e-11,
00464     4.308e-11, 4.102e-11, 3.887e-11, 3.682e-11, 3.521e-11, 3.369e-11,
00465     3.224e-11, 3.082e-11, 2.946e-11, 2.814e-11, 2.687e-11, 2.566e-11,
00466     2.449e-11, 2.336e-11, 2.227e-11, 2.123e-11, 2.023e-11, 1.927e-11,
00467     1.835e-11, 1.746e-11, 1.661e-11, 1.58e-11, 1.502e-11, 1.428e-11,
00468     1.357e-11, 1.289e-11, 1.224e-11, 1.161e-11, 1.102e-11, 1.045e-11,
00469     9.895e-12, 9.369e-12, 8.866e-12, 8.386e-12, 7.922e-12, 7.479e-12,
00470     7.06e-12, 6.656e-12, 6.274e-12, 5.914e-12, 5.575e-12, 5.257e-12,
00471     4.959e-12, 4.679e-12, 4.42e-12, 4.178e-12, 3.954e-12, 3.75e-12,
00472     3.557e-12, 3.372e-12, 3.198e-12, 3.047e-12, 2.908e-12, 2.775e-12,
00473     2.653e-12, 2.544e-12, 2.442e-12, 2.346e-12, 2.26e-12, 2.183e-12,
00474     2.11e-12, 2.044e-12, 1.98e-12, 1.924e-12, 1.871e-12, 1.821e-12,
00475     1.775e-12
00476   };
00477
00478   static double hcn[121] = {
00479     5.5e-10, 5.5e-10, 5.5e-10, 5.5e-10, 5.5e-10, 5.5e-10, 5.5e-10,
00480     5.5e-10, 5.5e-10, 5.5e-10, 5.5e-10, 5.498e-10, 5.495e-10, 5.493e-10,
00481     5.49e-10, 5.488e-10, 4.717e-10, 3.946e-10, 3.174e-10, 2.4e-10,
00482     1.626e-10, 1.619e-10, 1.612e-10, 1.602e-10, 1.593e-10, 1.582e-10,
00483     1.572e-10, 1.56e-10, 1.549e-10, 1.539e-10, 1.53e-10, 1.519e-10,
00484     1.506e-10, 1.487e-10, 1.467e-10, 1.449e-10, 1.43e-10, 1.413e-10,
00485     1.397e-10, 1.382e-10, 1.368e-10, 1.354e-10, 1.337e-10, 1.315e-10,
00486     1.292e-10, 1.267e-10, 1.241e-10, 1.215e-10, 1.19e-10, 1.165e-10,
00487     1.141e-10, 1.118e-10, 1.096e-10, 1.072e-10, 1.047e-10, 1.021e-10,
00488     9.968e-11, 9.739e-11, 9.539e-11, 9.339e-11, 9.135e-11, 8.898e-11,
00489     8.664e-11, 8.439e-11, 8.249e-11, 8.075e-11, 7.904e-11, 7.735e-11,
00490     7.565e-11, 7.399e-11, 7.245e-11, 7.109e-11, 6.982e-11, 6.863e-11,
00491     6.755e-11, 6.657e-11, 6.587e-11, 6.527e-11, 6.476e-11, 6.428e-11,
00492     6.382e-11, 6.343e-11, 6.307e-11, 6.272e-11, 6.238e-11, 6.205e-11,
00493     6.17e-11, 6.137e-11, 6.102e-11, 6.072e-11, 6.046e-11, 6.03e-11,
00494     6.018e-11, 6.01e-11, 6.001e-11, 5.992e-11, 5.984e-11, 5.975e-11,
00495     5.967e-11, 5.958e-11, 5.95e-11, 5.941e-11, 5.933e-11, 5.925e-11,
00496     5.916e-11, 5.908e-11, 5.899e-11, 5.891e-11, 5.883e-11, 5.874e-11,
00497     5.866e-11, 5.858e-11, 5.85e-11, 5.841e-11, 5.833e-11, 5.825e-11,
00498     5.817e-11, 5.808e-11, 5.8e-11, 5.792e-11, 5.784e-11
00499   };
00500
00501   static double hno3[121] = {
00502     1.809e-10, 7.234e-10, 5.899e-10, 4.342e-10, 3.277e-10, 2.661e-10,
00503     2.35e-10, 2.267e-10, 2.389e-10, 2.651e-10, 3.255e-10, 4.099e-10,
00504     5.42e-10, 6.978e-10, 8.807e-10, 1.112e-09, 1.405e-09, 2.04e-09,
00505     3.111e-09, 4.5e-09, 5.762e-09, 7.37e-09, 7.852e-09, 8.109e-09,
00506     8.067e-09, 7.554e-09, 7.076e-09, 6.268e-09, 5.524e-09, 4.749e-09,
00507     3.909e-09, 3.223e-09, 2.517e-09, 1.942e-09, 1.493e-09, 1.122e-09,
00508     8.449e-10, 6.361e-10, 4.787e-10, 3.611e-10, 2.804e-10, 2.215e-10,
00509     1.758e-10, 1.441e-10, 1.197e-10, 9.953e-11, 8.505e-11, 7.334e-11,
00510     6.325e-11, 5.625e-11, 5.058e-11, 4.548e-11, 4.122e-11, 3.748e-11,
00511     3.402e-11, 3.088e-11, 2.8e-11, 2.536e-11, 2.293e-11, 2.072e-11,
00512     1.871e-11, 1.687e-11, 1.52e-11, 1.368e-11, 1.23e-11, 1.105e-11,
00513     9.922e-12, 8.898e-12, 7.972e-12, 7.139e-12, 6.385e-12, 5.708e-12,
00514     5.099e-12, 4.549e-12, 4.056e-12, 3.613e-12, 3.216e-12, 2.862e-12,
00515     2.544e-12, 2.259e-12, 2.004e-12, 1.776e-12, 1.572e-12, 1.391e-12,
00516     1.227e-12, 1.082e-12, 9.528e-13, 8.379e-13, 7.349e-13, 6.436e-13,
00517     5.634e-13, 4.917e-13, 4.291e-13, 3.745e-13, 3.267e-13, 2.854e-13,
00518     2.494e-13, 2.181e-13, 1.913e-13, 1.68e-13, 1.479e-13, 1.31e-13,
00519     1.159e-13, 1.025e-13, 9.067e-14, 8.113e-14, 7.281e-14, 6.535e-14,
00520     5.892e-14, 5.348e-14, 4.867e-14, 4.439e-14, 4.073e-14, 3.76e-14,
00521     3.476e-14, 3.229e-14, 3e-14, 2.807e-14, 2.635e-14, 2.473e-14,
00522     2.332e-14
00523   };
00524
00525   static double hno4[121] = {
00526     6.118e-12, 3.594e-12, 2.807e-12, 3.04e-12, 4.458e-12, 7.986e-12,
00527     1.509e-11, 2.661e-11, 3.738e-11, 4.652e-11, 4.429e-11, 3.992e-11,
00528     3.347e-11, 3.005e-11, 3.173e-11, 4.055e-11, 5.812e-11, 8.489e-11,
00529     1.19e-10, 1.482e-10, 1.766e-10, 2.103e-10, 2.35e-10, 2.598e-10,
00530     2.801e-10, 2.899e-10, 3e-10, 2.817e-10, 2.617e-10, 2.332e-10,
00531     1.933e-10, 1.605e-10, 1.232e-10, 9.285e-11, 6.941e-11, 4.951e-11,
00532     3.539e-11, 2.402e-11, 1.522e-11, 9.676e-12, 6.056e-12, 3.745e-12,
00533     2.34e-12, 1.463e-12, 9.186e-13, 5.769e-13, 3.322e-13, 1.853e-13,
00534     1.035e-13, 7.173e-14, 5.382e-14, 4.036e-14, 3.401e-14, 2.997e-14,
00535     2.635e-14, 2.316e-14, 2.034e-14, 1.783e-14, 1.56e-14, 1.363e-14,
00536     1.19e-14, 1.037e-14, 9.032e-15, 7.846e-15, 6.813e-15, 5.912e-15,
00537     5.121e-15, 4.431e-15, 3.829e-15, 3.306e-15, 2.851e-15, 2.456e-15,
00538     2.114e-15, 1.816e-15, 1.559e-15, 1.337e-15, 1.146e-15, 9.811e-16,
00539     8.389e-16, 7.162e-16, 6.109e-16, 5.203e-16, 4.425e-16, 3.76e-16,
00540     3.184e-16, 2.692e-16, 2.274e-16, 1.917e-16, 1.61e-16, 1.35e-16,
00541     1.131e-16, 9.437e-17, 7.874e-17, 6.57e-17, 5.481e-17, 4.579e-17,
00542     3.828e-17, 3.204e-17, 2.691e-17, 2.264e-17, 1.912e-17, 1.626e-17,
00543     1.382e-17, 1.174e-17, 9.972e-18, 8.603e-18, 7.45e-18, 6.453e-18,
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00544     5.623e-18, 4.944e-18, 4.361e-18, 3.859e-18, 3.443e-18, 3.096e-18,
00545     2.788e-18, 2.528e-18, 2.293e-18, 2.099e-18, 1.929e-18, 1.773e-18,
00546     1.64e-18
00547   };
00548
00549   static double hocl[121] = {
00550     1.056e-12, 1.194e-12, 1.35e-12, 1.531e-12, 1.737e-12, 1.982e-12,
00551     2.263e-12, 2.599e-12, 2.991e-12, 3.459e-12, 4.012e-12, 4.662e-12,
00552     5.438e-12, 6.35e-12, 7.425e-12, 8.686e-12, 1.016e-11, 1.188e-11,
00553     1.389e-11, 1.659e-11, 2.087e-11, 2.621e-11, 3.265e-11, 4.064e-11,
00554     4.859e-11, 5.441e-11, 6.09e-11, 6.373e-11, 6.611e-11, 6.94e-11,
00555     7.44e-11, 7.97e-11, 8.775e-11, 9.722e-11, 1.064e-10, 1.089e-10,
00556     1.114e-10, 1.106e-10, 1.053e-10, 1.004e-10, 9.006e-11, 7.778e-11,
00557     6.739e-11, 5.636e-11, 4.655e-11, 3.845e-11, 3.042e-11, 2.368e-11,
00558     1.845e-11, 1.442e-11, 1.127e-11, 8.814e-12, 6.544e-12, 4.763e-12,
00559     3.449e-12, 2.612e-12, 1.999e-12, 1.526e-12, 1.16e-12, 8.793e-13,
00560     6.655e-13, 5.017e-13, 3.778e-13, 2.829e-13, 2.117e-13, 1.582e-13,
00561     1.178e-13, 8.755e-14, 6.486e-14, 4.799e-14, 3.54e-14, 2.606e-14,
00562     1.916e-14, 1.403e-14, 1.026e-14, 7.48e-15, 5.446e-15, 3.961e-15,
00563     2.872e-15, 2.076e-15, 1.498e-15, 1.077e-15, 7.726e-16, 5.528e-16,
00564     3.929e-16, 2.785e-16, 1.969e-16, 1.386e-16, 9.69e-17, 6.747e-17,
00565     4.692e-17, 3.236e-17, 2.232e-17, 1.539e-17, 1.061e-17, 7.332e-18,
00566     5.076e-18, 3.522e-18, 2.461e-18, 1.726e-18, 1.22e-18, 8.75e-19,
00567     6.264e-19, 4.482e-19, 3.207e-19, 2.368e-19, 1.762e-19, 1.312e-19,
00568     9.891e-20, 7.595e-20, 5.87e-20, 4.567e-20, 3.612e-20, 2.904e-20,
00569     2.343e-20, 1.917e-20, 1.568e-20, 1.308e-20, 1.1e-20, 9.25e-21,
00570     7.881e-21
00571   };
00572
00573   static double n2o[121] = {
00574     3.17e-07, 3.17e-07, 3.17e-07, 3.17e-07, 3.17e-07, 3.17e-07,
00575     3.17e-07, 3.17e-07, 3.17e-07, 3.124e-07, 3.077e-07, 3.03e-07,
00576     2.984e-07, 2.938e-07, 2.892e-07, 2.847e-07, 2.779e-07, 2.705e-07,
00577     2.631e-07, 2.557e-07, 2.484e-07, 2.345e-07, 2.201e-07, 2.01e-07,
00578     1.754e-07, 1.532e-07, 1.329e-07, 1.154e-07, 1.003e-07, 8.735e-08,
00579     7.617e-08, 6.512e-08, 5.547e-08, 4.709e-08, 3.915e-08, 3.259e-08,
00580     2.738e-08, 2.327e-08, 1.98e-08, 1.711e-08, 1.493e-08, 1.306e-08,
00581     1.165e-08, 1.049e-08, 9.439e-09, 8.375e-09, 7.391e-09, 6.525e-09,
00582     5.759e-09, 5.083e-09, 4.485e-09, 3.953e-09, 3.601e-09, 3.27e-09,
00583     2.975e-09, 2.757e-09, 2.556e-09, 2.37e-09, 2.195e-09, 2.032e-09,
00584     1.912e-09, 1.79e-09, 1.679e-09, 1.572e-09, 1.482e-09, 1.402e-09,
00585     1.326e-09, 1.254e-09, 1.187e-09, 1.127e-09, 1.071e-09, 1.02e-09,
00586     9.673e-10, 9.193e-10, 8.752e-10, 8.379e-10, 8.017e-10, 7.66e-10,
00587     7.319e-10, 7.004e-10, 6.721e-10, 6.459e-10, 6.199e-10, 5.942e-10,
00588     5.703e-10, 5.488e-10, 5.283e-10, 5.082e-10, 4.877e-10, 4.696e-10,
00589     4.52e-10, 4.355e-10, 4.198e-10, 4.039e-10, 3.888e-10, 3.754e-10,
00590     3.624e-10, 3.499e-10, 3.381e-10, 3.267e-10, 3.163e-10, 3.058e-10,
00591     2.959e-10, 2.864e-10, 2.77e-10, 2.686e-10, 2.604e-10, 2.534e-10,
00592     2.462e-10, 2.386e-10, 2.318e-10, 2.247e-10, 2.189e-10, 2.133e-10,
00593     2.071e-10, 2.014e-10, 1.955e-10, 1.908e-10, 1.86e-10, 1.817e-10
00594   };
00595
00596   static double n2o5[121] = {
00597     1.231e-11, 3.035e-12, 1.702e-12, 9.877e-13, 8.081e-13, 9.039e-13,
00598     1.169e-12, 1.474e-12, 1.651e-12, 1.795e-12, 1.998e-12, 2.543e-12,
00599     4.398e-12, 7.698e-12, 1.28e-11, 2.131e-11, 3.548e-11, 5.894e-11,
00600     7.645e-11, 1.089e-10, 1.391e-10, 1.886e-10, 2.386e-10, 2.986e-10,
00601     3.487e-10, 3.994e-10, 4.5e-10, 4.6e-10, 4.591e-10, 4.1e-10, 3.488e-10,
00602     2.846e-10, 2.287e-10, 1.696e-10, 1.011e-10, 6.428e-11, 4.324e-11,
00603     2.225e-11, 6.214e-12, 3.608e-12, 8.793e-13, 4.491e-13, 1.04e-13,
00604     6.1e-14, 3.436e-14, 6.671e-15, 1.171e-15, 5.848e-16, 1.212e-16,
00605     1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16,
00606     1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16,
00607     1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16,
00608     1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16,
00609     1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16,
00610     1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16,
00611     1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16, 1e-16,
00612     1e-16, 1e-16
00613   };
00614
00615   static double nh3[121] = {
00616     1e-10, 1e-10, 1e-10, 1e-10, 1e-10, 1e-10, 1e-10, 1e-10, 1e-10, 1e-10,
00617     1e-10, 1e-10, 1e-10, 1e-10, 9.444e-11, 8.488e-11, 7.241e-11, 5.785e-11,
00618     4.178e-11, 3.018e-11, 2.18e-11, 1.574e-11, 1.137e-11, 8.211e-12,
00619     5.973e-12, 4.327e-12, 3.118e-12, 2.234e-12, 1.573e-12, 1.04e-12,
00620     6.762e-13, 4.202e-13, 2.406e-13, 1.335e-13, 6.938e-14, 3.105e-14,
00621     1.609e-14, 1.033e-14, 6.432e-15, 4.031e-15, 2.555e-15, 1.656e-15,
00622     1.115e-15, 7.904e-16, 5.63e-16, 4.048e-16, 2.876e-16, 2.004e-16,
00623     1.356e-16, 9.237e-17, 6.235e-17, 4.223e-17, 3.009e-17, 2.328e-17,
00624     2.002e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17,
00625     1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17,
00626     1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17,
00627     1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17,
00628     1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17,
00629     1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17,
00630     1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17,
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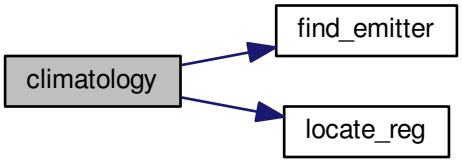
00631     1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17,
00632     1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17,
00633     1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17,
00634     1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17, 1.914e-17,
00635     1.914e-17
00636   };
00637
00638   static double no[121] = {
00639     2.586e-10, 4.143e-11, 1.566e-11, 9.591e-12, 8.088e-12, 8.462e-12,
00640     1.013e-11, 1.328e-11, 1.855e-11, 2.678e-11, 3.926e-11, 5.464e-11,
00641     7.012e-11, 8.912e-11, 1.127e-10, 1.347e-10, 1.498e-10, 1.544e-10,
00642     1.602e-10, 1.824e-10, 2.078e-10, 2.366e-10, 2.691e-10, 5.141e-10,
00643     8.259e-10, 1.254e-09, 1.849e-09, 2.473e-09, 3.294e-09, 4.16e-09,
00644     5.095e-09, 6.11e-09, 6.93e-09, 7.888e-09, 8.903e-09, 9.713e-09,
00645     1.052e-08, 1.115e-08, 1.173e-08, 1.21e-08, 1.228e-08, 1.239e-08,
00646     1.231e-08, 1.213e-08, 1.192e-08, 1.138e-08, 1.085e-08, 1.008e-08,
00647     9.224e-09, 8.389e-09, 7.262e-09, 6.278e-09, 5.335e-09, 4.388e-09,
00648     3.589e-09, 2.761e-09, 2.129e-09, 1.633e-09, 1.243e-09, 9.681e-10,
00649     8.355e-10, 7.665e-10, 7.442e-10, 8.584e-10, 9.732e-10, 1.063e-09,
00650     1.163e-09, 1.286e-09, 1.472e-09, 1.707e-09, 2.032e-09, 2.474e-09,
00651     2.977e-09, 3.506e-09, 4.102e-09, 5.013e-09, 6.493e-09, 8.414e-09,
00652     1.077e-08, 1.367e-08, 1.777e-08, 2.625e-08, 3.926e-08, 5.545e-08,
00653     7.195e-08, 9.464e-08, 1.404e-07, 2.183e-07, 3.329e-07, 4.535e-07,
00654     6.158e-07, 8.187e-07, 1.075e-06, 1.422e-06, 1.979e-06, 2.71e-06,
00655     3.58e-06, 4.573e-06, 5.951e-06, 7.999e-06, 1.072e-05, 1.372e-05,
00656     1.697e-05, 2.112e-05, 2.643e-05, 3.288e-05, 3.994e-05, 4.794e-05,
00657     5.606e-05, 6.383e-05, 7.286e-05, 8.156e-05, 8.883e-05, 9.469e-05,
00658     9.848e-05, 0.0001023, 0.0001066, 0.0001115, 0.0001145, 0.0001142,
00659     0.0001133
00660   };
00661
00662   static double no2[121] = {
00663     3.036e-09, 2.945e-10, 9.982e-11, 5.069e-11, 3.485e-11, 2.982e-11,
00664     2.947e-11, 3.164e-11, 3.714e-11, 4.586e-11, 6.164e-11, 8.041e-11,
00665     9.982e-11, 1.283e-10, 1.73e-10, 2.56e-10, 3.909e-10, 5.959e-10,
00666     9.081e-10, 1.384e-09, 1.788e-09, 2.189e-09, 2.686e-09, 3.091e-09,
00667     3.49e-09, 3.796e-09, 4.2e-09, 5.103e-09, 6.005e-09, 6.3e-09, 6.706e-09,
00668     7.07e-09, 7.434e-09, 7.663e-09, 7.788e-09, 7.8e-09, 7.597e-09,
00669     7.482e-09, 7.227e-09, 6.403e-09, 5.585e-09, 4.606e-09, 3.703e-09,
00670     2.984e-09, 2.183e-09, 1.48e-09, 8.441e-10, 5.994e-10, 3.799e-10,
00671     2.751e-10, 1.927e-10, 1.507e-10, 1.102e-10, 6.971e-11, 5.839e-11,
00672     3.904e-11, 3.087e-11, 2.176e-11, 1.464e-11, 1.209e-11, 8.497e-12,
00673     6.477e-12, 4.371e-12, 2.914e-12, 2.424e-12, 1.753e-12, 1.35e-12,
00674     9.417e-13, 6.622e-13, 5.148e-13, 3.841e-13, 3.446e-13, 3.01e-13,
00675     2.551e-13, 2.151e-13, 1.829e-13, 1.64e-13, 1.475e-13, 1.352e-13,
00676     1.155e-13, 9.963e-14, 9.771e-14, 9.577e-14, 9.384e-14, 9.186e-14,
00677     9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14,
00678     9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14,
00679     9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14,
00680     9e-14, 9e-14, 9e-14, 9e-14, 9e-14, 9e-14
00681   };
00682
00683   static double o3[121] = {
00684     2.218e-08, 3.394e-08, 3.869e-08, 4.219e-08, 4.501e-08, 4.778e-08,
00685     5.067e-08, 5.402e-08, 5.872e-08, 6.521e-08, 7.709e-08, 9.461e-08,
00686     1.269e-07, 1.853e-07, 2.723e-07, 3.964e-07, 5.773e-07, 8.2e-07,
00687     1.155e-06, 1.59e-06, 2.076e-06, 2.706e-06, 3.249e-06, 3.848e-06,
00688     4.459e-06, 4.986e-06, 5.573e-06, 5.958e-06, 6.328e-06, 6.661e-06,
00689     6.9e-06, 7.146e-06, 7.276e-06, 7.374e-06, 7.447e-06, 7.383e-06,
00690     7.321e-06, 7.161e-06, 6.879e-06, 6.611e-06, 6.216e-06, 5.765e-06,
00691     5.355e-06, 4.905e-06, 4.471e-06, 4.075e-06, 3.728e-06, 3.413e-06,
00692     3.125e-06, 2.856e-06, 2.607e-06, 2.379e-06, 2.17e-06, 1.978e-06,
00693     1.8e-06, 1.646e-06, 1.506e-06, 1.376e-06, 1.233e-06, 1.102e-06,
00694     9.839e-07, 8.771e-07, 7.814e-07, 6.947e-07, 6.102e-07, 5.228e-07,
00695     4.509e-07, 3.922e-07, 3.501e-07, 3.183e-07, 2.909e-07, 2.686e-07,
00696     2.476e-07, 2.284e-07, 2.109e-07, 2.003e-07, 2.013e-07, 2.022e-07,
00697     2.032e-07, 2.042e-07, 2.097e-07, 2.361e-07, 2.656e-07, 2.989e-07,
00698     3.37e-07, 3.826e-07, 4.489e-07, 5.26e-07, 6.189e-07, 7.312e-07,
00699     8.496e-07, 8.444e-07, 8.392e-07, 8.339e-07, 8.286e-07, 8.234e-07,
00700     8.181e-07, 8.129e-07, 8.077e-07, 8.026e-07, 6.918e-07, 5.176e-07,
00701     3.865e-07, 2.885e-07, 2.156e-07, 1.619e-07, 1.219e-07, 9.161e-08,
00702     6.972e-08, 5.399e-08, 3.498e-08, 2.111e-08, 1.322e-08, 8.482e-09,
00703     5.527e-09, 3.423e-09, 2.071e-09, 1.314e-09, 8.529e-10, 5.503e-10,
00704     3.665e-10
00705   };
00706
00707   static double ocs[121] = {
00708     6e-10, 6e-10, 6e-10, 6e-10, 6e-10, 6e-10, 6e-10, 6e-10, 6e-10, 5.997e-10,
00709     5.989e-10, 5.881e-10, 5.765e-10, 5.433e-10, 5.074e-10, 4.567e-10,
00710     4.067e-10, 3.601e-10, 3.093e-10, 2.619e-10, 2.232e-10, 1.805e-10,
00711     1.46e-10, 1.187e-10, 8.03e-11, 5.435e-11, 3.686e-11, 2.217e-11,
00712     1.341e-11, 8.756e-12, 4.511e-12, 2.37e-12, 1.264e-12, 8.28e-13,
00713     5.263e-13, 3.209e-13, 1.717e-13, 9.068e-14, 4.709e-14, 2.389e-14,
00714     1.236e-14, 1.127e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14,
00715     1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14,
00716     1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14,
00717     1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14,
```

```
00718     1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14,
00719     1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14,
00720     1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14,
00721     1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14,
00722     1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14,
00723     1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14,
00724     1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14,
00725     1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14,
00726     1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14, 1.091e-14,
00727     1.091e-14, 1.091e-14, 1.091e-14
00728   };
00729
00730   static double sf6[121] = {
00731     4.103e-12, 4.103e-12, 4.103e-12, 4.103e-12, 4.103e-12, 4.103e-12,
00732     4.103e-12, 4.103e-12, 4.103e-12, 4.087e-12, 4.064e-12, 4.023e-12,
00733     3.988e-12, 3.941e-12, 3.884e-12, 3.755e-12, 3.622e-12, 3.484e-12,
00734     3.32e-12, 3.144e-12, 2.978e-12, 2.811e-12, 2.653e-12, 2.489e-12,
00735     2.332e-12, 2.199e-12, 2.089e-12, 2.013e-12, 1.953e-12, 1.898e-12,
00736     1.859e-12, 1.826e-12, 1.798e-12, 1.776e-12, 1.757e-12, 1.742e-12,
00737     1.728e-12, 1.717e-12, 1.707e-12, 1.698e-12, 1.691e-12, 1.685e-12,
00738     1.679e-12, 1.675e-12, 1.671e-12, 1.668e-12, 1.665e-12, 1.663e-12,
00739     1.661e-12, 1.659e-12, 1.658e-12, 1.657e-12, 1.656e-12, 1.655e-12,
00740     1.654e-12, 1.653e-12, 1.653e-12, 1.652e-12, 1.652e-12, 1.652e-12,
00741     1.651e-12, 1.651e-12, 1.651e-12, 1.651e-12, 1.651e-12, 1.651e-12,
00742     1.651e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12,
00743     1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12,
00744     1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12,
00745     1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12,
00746     1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12,
00747     1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12,
00748     1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12,
00749     1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12, 1.65e-12
00750   };
00751
00752   static double so2[121] = {
00753     1e-10, 1e-10, 1e-10, 1e-10, 1e-10, 1e-10, 1e-10, 1e-10, 1e-10, 1e-10,
00754     1e-10, 1e-10, 9.867e-11, 9.537e-11, 9e-11, 8.404e-11, 7.799e-11,
00755     7.205e-11, 6.616e-11, 6.036e-11, 5.475e-11, 5.007e-11, 4.638e-11,
00756     4.346e-11, 4.055e-11, 3.763e-11, 3.471e-11, 3.186e-11, 2.905e-11,
00757     2.631e-11, 2.358e-11, 2.415e-11, 2.949e-11, 3.952e-11, 5.155e-11,
00758     6.76e-11, 8.741e-11, 1.099e-10, 1.278e-10, 1.414e-10, 1.512e-10,
00759     1.607e-10, 1.699e-10, 1.774e-10, 1.832e-10, 1.871e-10, 1.907e-10,
00760     1.943e-10, 1.974e-10, 1.993e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10,
00761     2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10,
00762     2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10,
00763     2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10,
00764     2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10,
00765     2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10,
00766     2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10,
00767     2e-10, 2e-10, 2e-10, 2e-10, 2e-10, 2e-10
00768   };
00769
00770   static int ig_co2 = -999;
00771
00772   double co2, *q[NG] = { NULL };
00773
00774   int ig, ip, iw, iz;
00775
00776   /* Find emitter index of CO2... */
00777   if (ig_co2 == -999)
00778     ig_co2 = find_emitter(ctl, "CO2");
00779
00780   /* Identify variable... */
00781   for (ig = 0; ig < ctl->ng; ig++) {
00782     q[ig] = NULL;
00783     if (strcasecmp(ctl->emitter[ig], "C2H2") == 0)
00784       q[ig] = c2h2;
00785     if (strcasecmp(ctl->emitter[ig], "C2H6") == 0)
00786       q[ig] = c2h6;
00787     if (strcasecmp(ctl->emitter[ig], "CCl4") == 0)
00788       q[ig] = ccl4;
00789     if (strcasecmp(ctl->emitter[ig], "CH4") == 0)
00790       q[ig] = ch4;
00791     if (strcasecmp(ctl->emitter[ig], "ClO") == 0)
00792       q[ig] = clo;
00793     if (strcasecmp(ctl->emitter[ig], "ClONO2") == 0)
00794       q[ig] = clono2;
00795     if (strcasecmp(ctl->emitter[ig], "CO") == 0)
00796       q[ig] = co;
00797     if (strcasecmp(ctl->emitter[ig], "COF2") == 0)
00798       q[ig] = cof2;
00799     if (strcasecmp(ctl->emitter[ig], "F11") == 0)
00800       q[ig] = f11;
00801     if (strcasecmp(ctl->emitter[ig], "F12") == 0)
00802       q[ig] = f12;
00803     if (strcasecmp(ctl->emitter[ig], "F14") == 0)
00804       q[ig] = f14;
```

```
00805     if (strcasecmp(ctl->emitter[ig], "F22") == 0)
00806       q[ig] = f22;
00807     if (strcasecmp(ctl->emitter[ig], "H2O") == 0)
00808       q[ig] = h2o;
00809     if (strcasecmp(ctl->emitter[ig], "H2O2") == 0)
00810       q[ig] = h2o2;
00811     if (strcasecmp(ctl->emitter[ig], "HCN") == 0)
00812       q[ig] = hcn;
00813     if (strcasecmp(ctl->emitter[ig], "HNO3") == 0)
00814       q[ig] = hno3;
00815     if (strcasecmp(ctl->emitter[ig], "HNO4") == 0)
00816       q[ig] = hno4;
00817     if (strcasecmp(ctl->emitter[ig], "HOCl") == 0)
00818       q[ig] = hocl;
00819     if (strcasecmp(ctl->emitter[ig], "N2O") == 0)
00820       q[ig] = n2o;
00821     if (strcasecmp(ctl->emitter[ig], "N2O5") == 0)
00822       q[ig] = n2o5;
00823     if (strcasecmp(ctl->emitter[ig], "NH3") == 0)
00824       q[ig] = nh3;
00825     if (strcasecmp(ctl->emitter[ig], "NO") == 0)
00826       q[ig] = no;
00827     if (strcasecmp(ctl->emitter[ig], "NO2") == 0)
00828       q[ig] = no2;
00829     if (strcasecmp(ctl->emitter[ig], "O3") == 0)
00830       q[ig] = o3;
00831     if (strcasecmp(ctl->emitter[ig], "OCS") == 0)
00832       q[ig] = ocs;
00833     if (strcasecmp(ctl->emitter[ig], "SF6") == 0)
00834       q[ig] = sf6;
00835     if (strcasecmp(ctl->emitter[ig], "SO2") == 0)
00836       q[ig] = so2;
00837   }
00838
00839   /* Loop over atmospheric data points... */
00840   for (ip = 0; ip < atm->np; ip++) {
00841
00842     /* Get altitude index... */
00843     iz = locate_reg(z, 121, atm->z[ip]);
00844
00845     /* Interpolate pressure... */
00846     atm->p[ip] = EXP(z[iz], pre[iz], z[iz + 1], pre[iz + 1], atm->z[ip]);
00847
00848     /* Interpolate temperature... */
00849     atm->t[ip] = LIN(z[iz], tem[iz], z[iz + 1], tem[iz + 1], atm->z[ip]);
00850
00851     /* Interpolate trace gases... */
00852     for (ig = 0; ig < ctl->ng; ig++)
00853       if (q[ig] != NULL)
00854         atm->q[ig][ip] =
00855           LIN(z[iz], q[ig][iz], z[iz + 1], q[ig][iz + 1], atm->z[ip]);
00856       else
00857         atm->q[ig][ip] = 0;
00858
00859     /* Set CO2... */
00860     if (ig_co2 >= 0) {
00861       co2 =
00862         371.789948e-6 + 2.026214e-6 * (atm->time[ip] - 63158400.) / 31557600.;
00863       atm->q[ig_co2][ip] = co2;
00864     }
00865
00866     /* Set extinction to zero... */
00867     for (iw = 0; iw < ctl->nw; iw++)
00868       atm->k[iw][ip] = 0;
00869   }
00870 }
```

Here is the call graph for this function:



5.15.2.6 double ctmco2 (double *nu*, double *p*, double *t*, double *u*)

Compute carbon dioxide continuum (optical depth).

Definition at line 874 of file jurassic.c.

```
00878             {
00879
00880   static double co2296[2001] = { 9.3388e-5, 9.7711e-5, 1.0224e-4, 1.0697e-4,
00881     1.1193e-4, 1.1712e-4, 1.2255e-4, 1.2824e-4, 1.3419e-4, 1.4043e-4,
00882     1.4695e-4, 1.5378e-4, 1.6094e-4, 1.6842e-4, 1.7626e-4, 1.8447e-4,
00883     1.9307e-4, 2.0207e-4, 2.1149e-4, 2.2136e-4, 2.3169e-4, 2.4251e-4,
00884     2.5384e-4, 2.657e-4, 2.7813e-4, 2.9114e-4, 3.0477e-4, 3.1904e-4,
00885     3.3399e-4, 3.4965e-4, 3.6604e-4, 3.8322e-4, 4.0121e-4, 4.2006e-4,
00886     4.398e-4, 4.6047e-4, 4.8214e-4, 5.0483e-4, 5.286e-4, 5.535e-4,
00887     5.7959e-4, 6.0693e-4, 6.3557e-4, 6.6558e-4, 6.9702e-4, 7.2996e-4,
00888     7.6449e-4, 8.0066e-4, 8.3856e-4, 8.7829e-4, 9.1991e-4, 9.6354e-4,
00889     .0010093, .0010572, .0011074, .00116, .0012152, .001273,
00890     .0013336, .0013972, .0014638, .0015336, .0016068, .0016835,
00891     .001764, .0018483, .0019367, .0020295, .0021267, .0022286,
00892     .0023355, .0024476, .0025652, .0026885, .0028178, .0029534,
00893     .0030956, .0032448, .0034012, .0035654, .0037375, .0039181,
00894     .0041076, .0043063, .0045148, .0047336, .0049632, .005204,
00895     .0054567, .0057219, .0060002, .0062923, .0065988, .0069204,
00896     .007258, .0076123, .0079842, .0083746, .0087844, .0092146,
00897     .0096663, .01014, .010638, .011161, .01171, .012286, .012891,
00898     .013527, .014194, .014895, .015631, .016404, .017217, .01807,
00899     .018966, .019908, .020897, .021936, .023028, .024176, .025382,
00900     .026649, .027981, .02938, .030851, .032397, .034023, .035732,
00901     .037528, .039416, .041402, .04349, .045685, .047994, .050422,
00902     .052975, .055661, .058486, .061458, .064584, .067873, .071334,
00903     .074975, .078807, .082839, .087082, .091549, .096249, .1012,
00904     .10641, .11189, .11767, .12375, .13015, .13689, .14399, .15147,
00905     .15935, .16765, .17639, .18561, .19531, .20554, .21632, .22769,
00906     .23967, .25229, .2656, .27964, .29443, .31004, .3265, .34386,
00907     .36218, .3815, .40188, .42339, .44609, .47004, .49533, .52202,
00908     .5502, .57995, .61137, .64455, .6796, .71663, .75574, .79707,
00909     .84075, .88691, .9357, .98728, 1.0418, 1.0995, 1.1605, 1.225,
00910     1.2932, 1.3654, 1.4418, 1.5227, 1.6083, 1.6989, 1.7948, 1.8964,
00911     2.004, 2.118, 2.2388, 2.3668, 2.5025, 2.6463, 2.7988, 2.9606,
00912     3.1321, 3.314, 3.5071, 3.712, 3.9296, 4.1605, 4.4058, 4.6663,
00913     4.9431, 5.2374, 5.5501, 5.8818, 6.2353, 6.6114, 7.0115, 7.4372,
00914     7.8905, 8.3731, 8.8871, 9.4349, 10.019, 10.641, 11.305, 12.013,
00915     12.769, 13.576, 14.437, 15.358, 16.342, 17.39, 18.513, 19.716,
00916     21.003, 22.379, 23.854, 25.436, 27.126, 28.942, 30.89, 32.973,
00917     35.219, 37.634, 40.224, 43.021, 46.037, 49.29, 52.803, 56.447,
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01542     7.6003e-5, 7.4119e-5, 7.2528e-5, 7.1216e-5, 7.0171e-5, 6.9385e-5,
01543     6.8848e-5, 6.8554e-5, 6.8496e-5, 6.8669e-5, 6.9069e-5, 6.9694e-5,
01544     7.054e-5, 7.1608e-5, 7.2896e-5, 7.4406e-5, 7.6139e-5, 7.8097e-5,
01545     8.0283e-5, 8.2702e-5, 8.5357e-5, 8.8255e-5, 9.1402e-5, 9.4806e-5,
01546     9.8473e-5, 1.0241e-4, 1.0664e-4, 1.1115e-4, 1.1598e-4, 1.2112e-4,
01547     1.2659e-4, 1.3241e-4, 1.3859e-4, 1.4515e-4, 1.521e-4, 1.5947e-4,
01548     1.6728e-4, 1.7555e-4, 1.8429e-4, 1.9355e-4, 2.0334e-4, 2.1369e-4,
01549     2.2463e-4, 2.3619e-4, 2.4841e-4, 2.6132e-4, 2.7497e-4, 2.8938e-4,
01550     3.0462e-4, 3.2071e-4, 3.3771e-4, 3.5567e-4, 3.7465e-4, 3.947e-4,
01551     4.1588e-4, 4.3828e-4, 4.6194e-4, 4.8695e-4, 5.1338e-4, 5.4133e-4,
01552     5.7087e-4, 6.0211e-4, 6.3515e-4, 6.701e-4, 7.0706e-4, 7.4617e-4,
01553     7.8756e-4, 8.3136e-4, 8.7772e-4, 9.2681e-4, 9.788e-4, .0010339,
01554     .0010922, .001154, .0012195, .0012889, .0013626, .0014407,
01555     .0015235, .0016114, .0017048, .0018038, .001909, .0020207,
01556     .0021395, .0022657, .0023998, .0025426, .0026944, .002856,
01557     .0030281, .0032114, .0034068, .003615, .0038371, .004074,
01558     .004327, .0045971, .0048857, .0051942, .0055239, .0058766,
01559     .0062538, .0066573, .0070891, .007551, .0080455, .0085747,
01560     .0091412, .0097481, .010397, .011092, .011837, .012638, .013495,
01561     .014415, .01541, .016475, .017621, .018857, .020175, .02162,
01562     .023185, .024876, .02672, .028732, .030916, .033319, .035939,
01563     .038736, .041847, .04524, .048715, .052678, .056977, .061203,
01564     .066184, .07164, .076952, .083477, .090674, .098049, .10697,
01565     .1169, .1277, .14011, .15323, .1684, .18601, .20626, .22831,
01566     .25417, .28407, .31405, .34957, .38823, .41923, .46026, .50409,
01567     .51227, .54805, .57976, .53818, .55056, .557, .46741, .46403,
01568     .4636, .42265, .45166, .49852, .56663, .34306, .17779, .17697,
01569     .18346, .19129, .20014, .21778, .23604, .25649, .28676, .31238,
01570     .33856, .39998, .4288, .46568, .56654, .60786, .64473, .76466,
01571     .7897, .80778, .86443, .85736, .84798, .84157, 1.1385, 1.2446,
01572     1.1923, 1.1552, 1.1338, 1.1266, 1.1292, 1.1431, 1.1683, 1.2059,
01573     1.2521, 1.3069, 1.3712, 1.4471, 1.5275, 1.6165, 1.7145, 1.8189,
01574     1.9359, 2.065, 2.2007, 2.3591, 2.5362, 2.7346, 2.9515, 3.2021,
01575     3.4851, 3.7935, 4.0694, 4.4463, 4.807, 5.2443, 5.7178, 6.2231,
01576     6.4796, 6.9461, 7.4099, 7.3652, 7.7182, 8.048, 7.7373, 8.0363,
01577     8.3855, 8.8044, 9.0257, 9.8574, 10.948, 10.563, 6.8979, 7.0744,
01578     7.4121, 7.7663, 8.1768, 8.6243, 9.1437, 9.7847, 10.182, 10.849,
01579     11.572, 12.602, 13.482, 14.431, 15.907, 16.983, 18.11, 19.884,
01580     21.02, 22.18, 23.355, 24.848, 25.954, 27.13, 30.186, 34.893,
01581     35.682, 36.755, 38.111, 39.703, 41.58, 43.606, 45.868, 48.573,
01582     51.298, 54.291, 57.559, 61.116, 64.964, 69.124, 73.628, 78.471,
01583     83.683, 89.307, 95.341, 101.84, 108.83, 116.36, 124.46, 133.18,
01584     142.57, 152.79, 163.69, 175.43, 188.11, 201.79, 216.55, 232.51,
01585     249.74, 268.38, 288.54, 310.35, 333.97, 359.55, 387.26, 417.3,
01586     449.88, 485.2, 523.54, 565.14, 610.28, 659.31, 712.56, 770.43,
01587     833.36, 901.82, 976.36, 1057.6, 1146.8, 1243.8, 1350., 1466.3,
01588     1593.6, 1732.7, 1884.1, 2049.1, 2228.2, 2421.9, 2629.4, 2853.7,
01589     3094.4, 3351.1, 3622.3, 3829.8, 4123.1, 4438.3, 4777.2, 5144.1,
01590     5545.4, 5990.5, 6404.5, 6996.8, 7687.6, 8482.9, 9349.4, 10203.,
01591     11223., 12358., 13493., 14916., 16416., 18236., 20222., 22501.,
01592     25102., 28358., 31707., 35404., 39538., 43911., 48391., 53193.,
01593     58028., 58082., 61276., 64193., 66294., 67480., 67921., 67423.,
01594     66254., 64341., 51737., 51420., 53072., 58145., 66195., 65358.,
01595     67377., 67869., 53509., 50553., 35737., 32425., 21704., 19974.,
01596     14457., 12142., 16798., 19489., 23049., 27270., 31910., 36457.,
01597     40877., 44748., 47876., 59793., 58626., 55454., 50337., 44893.,
01598     50228., 52216., 54747., 69541., 70455., 81014., 77694., 80533.,
01599     73953., 70927., 65539., 59002., 52281., 45953., 40292., 35360.,
01600     31124., 27478., 24346., 21647., 19308., 17271., 15491., 13927.,
01601     12550., 11331., 10250., 9288.8, 8431.4, 7664.9, 6978.3, 6361.8,
01602     5807.4, 5307.7, 4856.8, 4449., 4079.8, 3744.9, 3440.8, 3164.2,
01603     2912.3, 2682.7, 2473., 2281.4, 2106., 1945.3, 1797.9, 1662.5,
01604     1538.1, 1423.6, 1318.1, 1221., 1131.5, 1049., 972.99, 902.87,
01605     838.01, 777.95, 722.2, 670.44, 622.35, 577.68, 536.21, 497.76,
01606     462.12, 429.13, 398.61, 370.39, 344.29, 320.16, 297.85, 277.2,
01607     258.08, 240.38, 223.97, 208.77, 194.66, 181.58, 169.43, 158.15,
01608     147.67, 137.92, 128.86, 120.44, 112.6, 105.3, 98.499, 92.166,
01609     86.264, 80.763, 75.632, 70.846, 66.381, 62.213, 58.321, 54.685,
01610     51.288, 48.114, 45.145, 42.368, 39.772, 37.341, 35.065, 32.937,
01611     30.943, 29.077, 27.33, 25.693, 24.158, 22.717, 21.367, 20.099,
01612     18.909, 17.792, 16.744, 15.761, 14.838, 13.971, 13.157, 12.393,
01613     11.676, 11.003, 10.369, 9.775, 9.2165, 8.6902, 8.1963, 7.7314,
01614     7.2923, 6.8794, 6.4898, 6.122, 5.7764, 5.4525, 5.1484, 4.8611,
01615     4.5918, 4.3379, 4.0982, 3.8716, 3.6567, 3.4545, 3.2634, 3.0828,
01616     2.9122, 2.7512, 2.5993, 2.4561, 2.3211, 2.1938, 2.0737, 1.9603,
01617     1.8534, 1.7525, 1.6572, 1.5673, 1.4824, 1.4022, 1.3265, 1.2551,
01618     1.1876, 1.1239, 1.0637, 1.0069, .9532, .90248, .85454, .80921,
01619     .76631, .72569, .6872, .65072, .61635, .5836, .55261, .52336,
01620     .49581, .46998, .44559, .42236, .40036, .37929, .35924, .34043,
01621     .32238, .30547, .28931, .27405, .25975, .24616, .23341, .22133,
01622     .20997, .19924, .18917, .17967, .17075, .16211, .15411, .14646,
01623     .13912, .13201, .12509, .11857, .11261, .10698, .10186, .097039,
01624     .092236, .087844, .083443, .07938, .075452, .071564, .067931,
01625     .064389, .061078, .057901, .054921, .052061, .049364, .046789,
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01627     .030634, .029073, .027595, .026194, .024866, .023608, .022415,
01628     .021283, .02021, .019193, .018228, .017312, .016443, .015619,
01629     .014837, .014094, .01339, .012721, .012086, .011483, .010911,
01630     .010368, .009852, .0093623, .0088972, .0084556, .0080362,
01631     .0076379, .0072596, .0069003, .006559, .0062349, .0059269,
01632     .0056344, .0053565, .0050925, .0048417, .0046034, .004377,
01633     .0041618, .0039575, .0037633, .0035788, .0034034, .0032368,
01634     .0030785, .002928, .0027851, .0026492, .0025201, .0023975,
01635     .0022809, .0021701, .0020649, .0019649, .0018699, .0017796,
01636     .0016938, .0016122, .0015348, .0014612, .0013913, .001325,
01637     .0012619, .0012021, .0011452, .0010913, .0010401, 9.9149e-4,
01638     9.454e-4, 9.0169e-4, 8.6024e-4, 8.2097e-4, 7.8377e-4, 7.4854e-4,
01639     7.1522e-4, 6.8371e-4, 6.5393e-4, 6.2582e-4, 5.9932e-4, 5.7435e-4,
01640     5.5087e-4, 5.2882e-4, 5.0814e-4, 4.8881e-4, 4.7076e-4, 4.5398e-4,
01641     4.3843e-4, 4.2407e-4, 4.109e-4, 3.9888e-4, 3.88e-4, 3.7826e-4,
01642     3.6963e-4, 3.6213e-4, 3.5575e-4, 3.505e-4, 3.464e-4, 3.4346e-4,
01643     3.4173e-4, 3.4125e-4, 3.4206e-4, 3.4424e-4, 3.4787e-4, 3.5303e-4,
01644     3.5986e-4, 3.6847e-4, 3.7903e-4, 3.9174e-4, 4.0681e-4, 4.2455e-4,
01645     4.4527e-4, 4.6942e-4, 4.9637e-4, 5.2698e-4, 5.5808e-4, 5.9514e-4,
01646     6.2757e-4, 6.689e-4, 7.1298e-4, 7.3955e-4, 7.8403e-4, 8.0449e-4,
01647     8.5131e-4, 9.0256e-4, 9.3692e-4, .0010051, .0010846, .0011678,
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01652     .0043851, .004253, .003738, .0038084, .0039013, .0041505,
01653     .0045372, .0050569, .0054507, .0061267, .0066122, .0072449,
01654     .0078012, .0082651, .0076538, .0076573, .0076806, .0075227,
01655     .0076269, .0063758, .006254, .0067749, .0067909, .0068231,
01656     .0072143, .0072762, .0072954, .007679, .0075107, .0073658,
01657     .0072441, .0071074, .0070378, .007176, .0072472, .0075844,
01658     .0079291, .008412, .0090165, .010688, .011535, .012375, .013166,
01659     .013895, .015567, .016011, .016392, .016737, .017043, .017731,
01660     .018031, .018419, .018877, .019474, .019868, .020604, .021538,
01661     .022653, .023869, .025288, .026879, .028547, .030524, .03274,
01662     .035132, .03769, .040567, .043793, .047188, .049962, .053542,
01663     .057205, .060776, .061489, .064419, .067124, .065945, .068487,
01664     .071209, .074783, .077039, .082444, .08902, .09692, .10617,
01665     .11687, .12952, .12362, .13498, .14412, .15492, .16519, .1744,
01666     .17096, .17714, .18208, .17363, .17813, .18564, .18295, .19045,
01667     .20252, .20815, .21844, .22929, .24229, .25321, .26588, .2797,
01668     .29465, .31136, .32961, .36529, .38486, .41027, .43694, .4667,
01669     .49943, .54542, .58348, .62303, .67633, .71755, .76054, .81371,
01670     .85934, .90841, .96438, 1.0207, 1.0821, 1.1491, 1.2226, 1.3018,
01671     1.388, 1.4818, 1.5835, 1.6939, 1.8137, 1.9435, 2.0843, 2.237,
01672     2.4026, 2.5818, 2.7767, 2.9885, 3.2182, 3.4679, 3.7391, 4.0349,
01673     4.3554, 4.7053, 5.0849, 5.4986, 5.9436, 6.4294, 6.9598, 7.5203,
01674     8.143, 8.8253, 9.5568, 10.371, 11.267, 12.233, 13.31, 14.357,
01675     15.598, 16.93, 18.358, 19.849, 21.408, 23.04, 24.706, 26.409,
01676     28.153, 28.795, 30.549, 32.43, 34.49, 36.027, 38.955, 42.465,
01677     46.565, 50.875, 55.378, 59.002, 63.882, 67.949, 73.693, 80.095,
01678     86.403, 94.264, 102.65, 112.37, 123.3, 135.54, 149.14, 163.83,
01679     179.17, 196.89, 217.91, 240.94, 264.13, 292.39, 324.83, 358.21,
01680     397.16, 440.5, 488.6, 541.04, 595.3, 650.43, 652.03, 688.74,
01681     719.47, 743.54, 757.68, 762.35, 756.43, 741.42, 595.43, 580.97,
01682     580.83, 605.68, 667.88, 764.49, 759.93, 789.12, 798.17, 645.66,
01683     615.65, 455.05, 421.09, 306.45, 289.14, 235.7, 215.52, 274.57,
01684     316.53, 357.73, 409.89, 465.06, 521.84, 579.02, 630.64, 794.46,
01685     813., 813.56, 796.25, 761.57, 727.97, 812.14, 866.75, 932.5,
01686     1132.8, 1194.8, 1362.2, 1387.2, 1482.3, 1479.7, 1517.9, 1533.1,
01687     1534.2, 1523.3, 1522.5, 1515.5, 1505.2, 1486.5, 1454., 1412.,
01688     1358.8, 1107.8, 1060.9, 1033.5, 1048.2, 1122.4, 1248.9, 1227.1,
01689     1255.4, 1058.9, 1020.7, 970.59, 715.24, 512.56, 468.47, 349.3,
01690     338.26, 299.22, 301.26, 332.38, 382.08, 445.49, 515.87, 590.85,
01691     662.3, 726.05, 955.59, 964.11, 945.17, 891.48, 807.11, 720.9,
01692     803.36, 834.46, 1073.9, 1107.1, 1123.6, 1296., 1393.7, 1303.1,
01693     1284.3, 1161.8, 1078.8, 976.13, 868.72, 767.4, 674.72, 593.73,
01694     523.12, 462.24, 409.75, 364.34, 325., 290.73, 260.76, 234.46,
01695     211.28, 190.78, 172.61, 156.44, 142.01, 129.12, 117.57, 107.2,
01696     97.877, 89.47, 81.882, 75.021, 68.807, 63.171, 58.052, 53.396,
01697     49.155, 45.288, 41.759, 38.531, 35.576, 32.868, 30.384, 28.102,
01698     26.003, 24.071, 22.293, 20.655, 19.147, 17.756, 16.476, 15.292,
01699     14.198, 13.183, 12.241, 11.367, 10.554, 9.7989, 9.0978, 8.4475,
01700     7.845, 7.2868, 6.7704, 6.2927, 5.8508, 5.4421, 5.064, 4.714,
01701     4.3902, 4.0902, 3.8121, 3.5543, 3.315, 3.093, 2.8869, 2.6953,
01702     2.5172, 2.3517, 2.1977, 2.0544, 1.9211, 1.7969, 1.6812, 1.5735,
01703     1.4731, 1.3794, 1.2921, 1.2107, 1.1346, 1.0637, .99744, .93554,
01704     .87771, .82368, .77313, .72587, .6816, .64014, .60134, .565,
01705     .53086, .49883, .46881, .44074, .4144, .38979, .36679, .34513,
01706     .32474, .30552, .28751, .27045, .25458, .23976, .22584, .21278,
01707     .20051, .18899, .17815, .16801, .15846, .14954, .14117, .13328,
01708     .12584
01709   };
01710
01711   double xw, dw, ew, cw296, cw260, cw230, dt230, dt260, dt296, ctw, ctmpth;
01712
```

```
01713   int iw;
01714
01715   /* Get CO2 continuum absorption... */
01716   xw = nu / 2 + 1;
01717   if (xw >= 1 && xw < 2001) {
01718     iw = (int) xw;
01719     dw = xw - iw;
01720     ew = 1 - dw;
01721     cw296 = ew * co2296[iw - 1] + dw * co2296[iw];
01722     cw260 = ew * co2260[iw - 1] + dw * co2260[iw];
01723     cw230 = ew * co2230[iw - 1] + dw * co2230[iw];
01724     dt230 = t - 230;
01725     dt260 = t - 260;
01726     dt296 = t - 296;
01727     ctw = dt260 * 5.050505e-4 * dt296 * cw230 - dt230 * 9.259259e-4
01728       * dt296 * cw260 + dt230 * 4.208754e-4 * dt260 * cw296;
01729     ctmpth = u / NA / 1000 * p / P0 * ctw;
01730   } else
01731     ctmpth = 0;
01732   return ctmpth;
01733 }
```

5.15.2.7 double ctmh2o (double *nu*, double *p*, double *t*, double *q*, double *u*)

Compute water vapor continuum (optical depth).

Definition at line 1737 of file jurassic.c.

```
01742             {
01743
01744   static double h2o296[2001] = { .17, .1695, .172, .168, .1687, .1624, .1606,
01745     .1508, .1447, .1344, .1214, .1133, .1009, .09217, .08297, .06989,
01746     .06513, .05469, .05056, .04417, .03779, .03484, .02994, .0272,
01747     .02325, .02063, .01818, .01592, .01405, .01251, .0108, .009647,
01748     .008424, .007519, .006555, .00588, .005136, .004511, .003989,
01749     .003509, .003114, .00274, .002446, .002144, .001895, .001676,
01750     .001486, .001312, .001164, .001031, 9.129e-4, 8.106e-4, 7.213e-4,
01751     6.4e-4, 5.687e-4, 5.063e-4, 4.511e-4, 4.029e-4, 3.596e-4,
01752     3.22e-4, 2.889e-4, 2.597e-4, 2.337e-4, 2.108e-4, 1.907e-4,
01753     1.728e-4, 1.57e-4, 1.43e-4, 1.305e-4, 1.195e-4, 1.097e-4,
01754     1.009e-4, 9.307e-5, 8.604e-5, 7.971e-5, 7.407e-5, 6.896e-5,
01755     6.433e-5, 6.013e-5, 5.631e-5, 5.283e-5, 4.963e-5, 4.669e-5,
01756     4.398e-5, 4.148e-5, 3.917e-5, 3.702e-5, 3.502e-5, 3.316e-5,
01757     3.142e-5, 2.978e-5, 2.825e-5, 2.681e-5, 2.546e-5, 2.419e-5,
01758     2.299e-5, 2.186e-5, 2.079e-5, 1.979e-5, 1.884e-5, 1.795e-5,
01759     1.711e-5, 1.633e-5, 1.559e-5, 1.49e-5, 1.426e-5, 1.367e-5,
01760     1.312e-5, 1.263e-5, 1.218e-5, 1.178e-5, 1.143e-5, 1.112e-5,
01761     1.088e-5, 1.07e-5, 1.057e-5, 1.05e-5, 1.051e-5, 1.059e-5,
01762     1.076e-5, 1.1e-5, 1.133e-5, 1.18e-5, 1.237e-5, 1.308e-5,
01763     1.393e-5, 1.483e-5, 1.614e-5, 1.758e-5, 1.93e-5, 2.123e-5,
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01765     4.813e-5, 5.477e-5, 6.203e-5, 7.331e-5, 8.056e-5, 9.882e-5,
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02617     5.154e-11, 4.428e-11, 3.913e-11, 3.521e-11, 3.297e-11, 3.275e-11,
02618     3.46e-11, 3.798e-11, 4.251e-11, 4.745e-11, 5.232e-11, 5.606e-11,
02619     5.82e-11, 5.88e-11, 5.79e-11, 5.661e-11, 5.491e-11, 5.366e-11,
02620     5.341e-11, 5.353e-11, 5.336e-11, 5.293e-11, 5.248e-11, 5.235e-11,
02621     5.208e-11, 5.322e-11, 5.521e-11, 5.725e-11, 5.827e-11, 5.685e-11,
02622     5.245e-11, 4.612e-11, 3.884e-11, 3.129e-11, 2.404e-11, 1.732e-11,
02623     1.223e-11, 8.574e-12, 5.888e-12, 3.986e-12, 2.732e-12, 1.948e-12,
02624     1.414e-12, 1.061e-12, 8.298e-13, 6.612e-13, 5.413e-13, 4.472e-13,
02625     3.772e-13, 3.181e-13, 2.645e-13, 2.171e-13, 1.778e-13, 1.464e-13,
02626     1.183e-13, 9.637e-14, 7.991e-14, 6.668e-14, 5.57e-14, 4.663e-14,
02627     3.848e-14, 3.233e-14, 2.706e-14, 2.284e-14, 1.944e-14, 1.664e-14,
02628     1.43e-14, 1.233e-14, 1.066e-14, 9.234e-15, 8.023e-15, 6.993e-15,
02629     6.119e-15, 5.384e-15, 4.774e-15, 4.283e-15, 3.916e-15, 3.695e-15,
02630     3.682e-15, 4.004e-15, 4.912e-15, 6.853e-15, 1.056e-14, 1.712e-14,
02631     2.804e-14, 4.516e-14, 7.113e-14, 1.084e-13, 1.426e-13, 1.734e-13,
02632     1.978e-13, 2.194e-13, 2.388e-13, 2.489e-13, 2.626e-13, 2.865e-13,
02633     3.105e-13, 3.387e-13, 3.652e-13, 3.984e-13, 4.398e-13, 4.906e-13,
02634     5.55e-13, 6.517e-13, 7.813e-13, 9.272e-13, 1.164e-12, 1.434e-12,
02635     1.849e-12, 2.524e-12, 3.328e-12, 4.523e-12, 6.108e-12, 8.207e-12,
02636     1.122e-11, 1.477e-11, 1.9e-11, 2.412e-11, 2.984e-11, 3.68e-11,
02637     4.353e-11, 4.963e-11, 5.478e-11, 5.903e-11, 6.233e-11, 6.483e-11,
02638     6.904e-11, 7.569e-11, 8.719e-11, 1.048e-10, 1.278e-10, 1.557e-10,
02639     1.869e-10, 2.218e-10, 2.61e-10, 2.975e-10, 3.371e-10, 3.746e-10,
02640     4.065e-10, 4.336e-10, 4.503e-10, 4.701e-10, 4.8e-10, 4.917e-10,
02641     5.038e-10, 5.128e-10, 5.143e-10, 5.071e-10, 5.019e-10, 5.025e-10,
02642     5.183e-10, 5.496e-10, 5.877e-10, 6.235e-10, 6.42e-10, 6.234e-10,
02643     5.698e-10, 4.916e-10, 4.022e-10, 3.126e-10, 2.282e-10, 1.639e-10,
02644     1.142e-10, 7.919e-11, 5.69e-11, 4.313e-11, 3.413e-11, 2.807e-11,
02645     2.41e-11, 2.166e-11, 2.024e-11, 1.946e-11, 1.929e-11, 1.963e-11,
02646     2.035e-11, 2.162e-11, 2.305e-11, 2.493e-11, 2.748e-11, 3.048e-11,
02647     3.413e-11, 3.754e-11, 4.155e-11, 4.635e-11, 5.11e-11, 5.734e-11,
02648     6.338e-11, 6.99e-11, 7.611e-11, 8.125e-11, 8.654e-11, 8.951e-11,
02649     9.182e-11, 9.31e-11, 9.273e-11, 9.094e-11, 8.849e-11, 8.662e-11,
02650     8.67e-11, 8.972e-11, 9.566e-11, 1.025e-10, 1.083e-10, 1.111e-10,
02651     1.074e-10, 9.771e-11, 8.468e-11, 6.958e-11, 5.47e-11, 4.04e-11,
02652     2.94e-11, 2.075e-11, 1.442e-11, 1.01e-11, 7.281e-12, 5.409e-12,
02653     4.138e-12, 3.304e-12, 2.784e-12, 2.473e-12, 2.273e-12, 2.186e-12,
02654     2.118e-12, 2.066e-12, 1.958e-12, 1.818e-12, 1.675e-12, 1.509e-12,
02655     1.349e-12, 1.171e-12, 9.838e-13, 8.213e-13, 6.765e-13, 5.378e-13,
02656     4.161e-13, 3.119e-13, 2.279e-13, 1.637e-13, 1.152e-13, 8.112e-14,
02657     5.919e-14, 4.47e-14, 3.492e-14, 2.811e-14, 2.319e-14, 1.948e-14,
02658     1.66e-14, 1.432e-14, 1.251e-14, 1.109e-14, 1.006e-14, 9.45e-15,
02659     9.384e-15, 1.012e-14, 1.216e-14, 1.636e-14, 2.305e-14, 3.488e-14,
02660     5.572e-14, 8.479e-14, 1.265e-13, 1.905e-13, 2.73e-13, 3.809e-13,
02661     4.955e-13, 6.303e-13, 7.861e-13, 9.427e-13, 1.097e-12, 1.212e-12,
02662     1.328e-12, 1.415e-12, 1.463e-12, 1.495e-12, 1.571e-12, 1.731e-12,
02663     1.981e-12, 2.387e-12, 2.93e-12, 3.642e-12, 4.584e-12, 5.822e-12,
```

```
02664     7.278e-12, 9.193e-12, 1.135e-11, 1.382e-11, 1.662e-11, 1.958e-11,
02665     2.286e-11, 2.559e-11, 2.805e-11, 2.988e-11, 3.106e-11, 3.182e-11,
02666     3.2e-11, 3.258e-11, 3.362e-11, 3.558e-11, 3.688e-11, 3.8e-11,
02667     3.929e-11, 4.062e-11, 4.186e-11, 4.293e-11, 4.48e-11, 4.643e-11,
02668     4.704e-11, 4.571e-11, 4.206e-11, 3.715e-11, 3.131e-11, 2.541e-11,
02669     1.978e-11, 1.508e-11, 1.146e-11, 8.7e-12, 6.603e-12, 5.162e-12,
02670     4.157e-12, 3.408e-12, 2.829e-12, 2.405e-12, 2.071e-12, 1.826e-12,
02671     1.648e-12, 1.542e-12, 1.489e-12, 1.485e-12, 1.493e-12, 1.545e-12,
02672     1.637e-12, 1.814e-12, 2.061e-12, 2.312e-12, 2.651e-12, 3.03e-12,
02673     3.46e-12, 3.901e-12, 4.306e-12, 4.721e-12, 5.008e-12, 5.281e-12,
02674     5.541e-12, 5.791e-12, 6.115e-12, 6.442e-12, 6.68e-12, 6.791e-12,
02675     6.831e-12, 6.839e-12, 6.946e-12, 7.128e-12, 7.537e-12, 8.036e-12,
02676     8.392e-12, 8.526e-12, 8.11e-12, 7.325e-12, 6.329e-12, 5.183e-12,
02677     4.081e-12, 2.985e-12, 2.141e-12, 1.492e-12, 1.015e-12, 6.684e-13,
02678     4.414e-13, 2.987e-13, 2.038e-13, 1.391e-13, 9.86e-14, 7.24e-14,
02679     5.493e-14, 4.288e-14, 3.427e-14, 2.787e-14, 2.296e-14, 1.909e-14,
02680     1.598e-14, 1.344e-14, 1.135e-14, 9.616e-15, 8.169e-15, 6.957e-15,
02681     5.938e-15, 5.08e-15, 4.353e-15, 3.738e-15, 3.217e-15, 2.773e-15,
02682     2.397e-15, 2.077e-15, 1.805e-15, 1.575e-15, 1.382e-15, 1.221e-15,
02683     1.09e-15, 9.855e-16, 9.068e-16, 8.537e-16, 8.27e-16, 8.29e-16,
02684     8.634e-16, 9.359e-16, 1.055e-15, 1.233e-15, 1.486e-15, 1.839e-15,
02685     2.326e-15, 2.998e-15, 3.934e-15, 5.256e-15, 7.164e-15, 9.984e-15,
02686     1.427e-14, 2.099e-14, 3.196e-14, 5.121e-14, 7.908e-14, 1.131e-13,
02687     1.602e-13, 2.239e-13, 3.075e-13, 4.134e-13, 5.749e-13, 7.886e-13,
02688     1.071e-12, 1.464e-12, 2.032e-12, 2.8e-12, 3.732e-12, 4.996e-12,
02689     6.483e-12, 8.143e-12, 1.006e-11, 1.238e-11, 1.484e-11, 1.744e-11,
02690     2.02e-11, 2.274e-11, 2.562e-11, 2.848e-11, 3.191e-11, 3.617e-11,
02691     4.081e-11, 4.577e-11, 4.937e-11, 5.204e-11, 5.401e-11, 5.462e-11,
02692     5.507e-11, 5.51e-11, 5.605e-11, 5.686e-11, 5.739e-11, 5.766e-11,
02693     5.74e-11, 5.754e-11, 5.761e-11, 5.777e-11, 5.712e-11, 5.51e-11,
02694     5.088e-11, 4.438e-11, 3.728e-11, 2.994e-11, 2.305e-11, 1.715e-11,
02695     1.256e-11, 9.208e-12, 6.745e-12, 5.014e-12, 3.785e-12, 2.9e-12,
02696     2.239e-12, 1.757e-12, 1.414e-12, 1.142e-12, 9.482e-13, 8.01e-13,
02697     6.961e-13, 6.253e-13, 5.735e-13, 5.433e-13, 5.352e-13, 5.493e-13,
02698     5.706e-13, 6.068e-13, 6.531e-13, 7.109e-13, 7.767e-13, 8.59e-13,
02699     9.792e-13, 1.142e-12, 1.371e-12, 1.65e-12, 1.957e-12, 2.302e-12,
02700     2.705e-12, 3.145e-12, 3.608e-12, 4.071e-12, 4.602e-12, 5.133e-12,
02701     5.572e-12, 5.987e-12, 6.248e-12, 6.533e-12, 6.757e-12, 6.935e-12,
02702     7.224e-12, 7.422e-12, 7.538e-12, 7.547e-12, 7.495e-12, 7.543e-12,
02703     7.725e-12, 8.139e-12, 8.627e-12, 9.146e-12, 9.443e-12, 9.318e-12,
02704     8.649e-12, 7.512e-12, 6.261e-12, 4.915e-12, 3.647e-12, 2.597e-12,
02705     1.785e-12, 1.242e-12, 8.66e-13, 6.207e-13, 4.61e-13, 3.444e-13,
02706     2.634e-13, 2.1e-13, 1.725e-13, 1.455e-13, 1.237e-13, 1.085e-13,
02707     9.513e-14, 7.978e-14, 6.603e-14, 5.288e-14, 4.084e-14, 2.952e-14,
02708     2.157e-14, 1.593e-14, 1.199e-14, 9.267e-15, 7.365e-15, 6.004e-15,
02709     4.995e-15, 4.218e-15, 3.601e-15, 3.101e-15, 2.692e-15, 2.36e-15,
02710     2.094e-15, 1.891e-15, 1.755e-15, 1.699e-15, 1.755e-15, 1.987e-15,
02711     2.506e-15, 3.506e-15, 5.289e-15, 8.311e-15, 1.325e-14, 2.129e-14,
02712     3.237e-14, 4.595e-14, 6.441e-14, 8.433e-14, 1.074e-13, 1.383e-13,
02713     1.762e-13, 2.281e-13, 2.831e-13, 3.523e-13, 4.38e-13, 5.304e-13,
02714     6.29e-13, 7.142e-13, 8.032e-13, 8.934e-13, 9.888e-13, 1.109e-12,
02715     1.261e-12, 1.462e-12, 1.74e-12, 2.099e-12, 2.535e-12, 3.008e-12,
02716     3.462e-12, 3.856e-12, 4.098e-12, 4.239e-12, 4.234e-12, 4.132e-12,
02717     3.986e-12, 3.866e-12, 3.829e-12, 3.742e-12, 3.705e-12, 3.694e-12,
02718     3.765e-12, 3.849e-12, 3.929e-12, 4.056e-12, 4.092e-12, 4.047e-12,
02719     3.792e-12, 3.407e-12, 2.953e-12, 2.429e-12, 1.931e-12, 1.46e-12,
02720     1.099e-12, 8.199e-13, 6.077e-13, 4.449e-13, 3.359e-13, 2.524e-13,
02721     1.881e-13, 1.391e-13, 1.02e-13, 7.544e-14, 5.555e-14, 4.22e-14,
02722     3.321e-14, 2.686e-14, 2.212e-14, 1.78e-14, 1.369e-14, 1.094e-14,
02723     9.13e-15, 8.101e-15, 7.828e-15, 8.393e-15, 1.012e-14, 1.259e-14,
02724     1.538e-14, 1.961e-14, 2.619e-14, 3.679e-14, 5.049e-14, 6.917e-14,
02725     8.88e-14, 1.115e-13, 1.373e-13, 1.619e-13, 1.878e-13, 2.111e-13,
02726     2.33e-13, 2.503e-13, 2.613e-13, 2.743e-13, 2.826e-13, 2.976e-13,
02727     3.162e-13, 3.36e-13, 3.491e-13, 3.541e-13, 3.595e-13, 3.608e-13,
02728     3.709e-13, 3.869e-13, 4.12e-13, 4.366e-13, 4.504e-13, 4.379e-13,
02729     3.955e-13, 3.385e-13, 2.741e-13, 2.089e-13, 1.427e-13, 9.294e-14,
02730     5.775e-14, 3.565e-14, 2.21e-14, 1.398e-14, 9.194e-15, 6.363e-15,
02731     4.644e-15, 3.55e-15, 2.808e-15, 2.274e-15, 1.871e-15, 1.557e-15,
02732     1.308e-15, 1.108e-15, 9.488e-16, 8.222e-16, 7.238e-16, 6.506e-16,
02733     6.008e-16, 5.742e-16, 5.724e-16, 5.991e-16, 6.625e-16, 7.775e-16,
02734     9.734e-16, 1.306e-15, 1.88e-15, 2.879e-15, 4.616e-15, 7.579e-15,
02735     1.248e-14, 2.03e-14, 3.244e-14, 5.171e-14, 7.394e-14, 9.676e-14,
02736     1.199e-13, 1.467e-13, 1.737e-13, 2.02e-13, 2.425e-13, 3.016e-13,
02737     3.7e-13, 4.617e-13, 5.949e-13, 7.473e-13, 9.378e-13, 1.191e-12,
02738     1.481e-12, 1.813e-12, 2.232e-12, 2.722e-12, 3.254e-12, 3.845e-12,
02739     4.458e-12, 5.048e-12, 5.511e-12, 5.898e-12, 6.204e-12, 6.293e-12,
02740     6.386e-12, 6.467e-12, 6.507e-12, 6.466e-12, 6.443e-12, 6.598e-12,
02741     6.873e-12, 7.3e-12, 7.816e-12, 8.368e-12, 8.643e-12, 8.466e-12,
02742     7.871e-12, 6.853e-12, 5.714e-12, 4.482e-12, 3.392e-12, 2.613e-12,
02743     2.008e-12, 1.562e-12, 1.228e-12, 9.888e-13, 7.646e-13, 5.769e-13,
02744     4.368e-13, 3.324e-13, 2.508e-13, 1.916e-13
02745   };
02746
02747   static double xfcrev[15] =
02748     { 1.003, 1.009, 1.015, 1.023, 1.029, 1.033, 1.037,
02749     1.039, 1.04, 1.046, 1.036, 1.027, 1.01, 1.002, 1.
02750   };
```

```
02751
02752   double a1, a2, a3, dw, ew, dx, xw, xx, vf2, vf6, cw260, cw296,
02753     sfac, fscal, cwfrn, ctmpth, ctwfrn, ctwslf;
02754
02755   int iw, ix;
02756
02757   /* Get H2O continuum absorption... */
02758   xw = nu / 10 + 1;
02759   if (xw >= 1 && xw < 2001) {
02760     iw = (int) xw;
02761     dw = xw - iw;
02762     ew = 1 - dw;
02763     cw296 = ew * h2o296[iw - 1] + dw * h2o296[iw];
02764     cw260 = ew * h2o260[iw - 1] + dw * h2o260[iw];
02765     cwfrn = ew * h2ofrn[iw - 1] + dw * h2ofrn[iw];
02766     if (nu <= 820 || nu >= 960) {
02767       sfac = 1;
02768     } else {
02769       xx = (nu - 820) / 10;
02770       ix = (int) xx;
02771       dx = xx - ix;
02772       sfac = (1 - dx) * xfcrev[ix] + dx * xfcrev[ix + 1];
02773     }
02774     ctwslf = sfac * cw296 * pow(cw260 / cw296, (296 - t) / (296 - 260));
02775     vf2 = POW2(nu - 370);
02776     vf6 = POW3(vf2);
02777     fscal = 36100 / (vf2 + vf6 * 1e-8 + 36100) * -.25 + 1;
02778     ctwfrn = cwfrn * fscal;
02779     a1 = nu * u * tanh(.7193876 / t * nu);
02780     a2 = 296 / t;
02781     a3 = p / P0 * (q * ctwslf + (1 - q) * ctwfrn) * 1e-20;
02782     ctmpth = a1 * a2 * a3;
02783   } else
02784     ctmpth = 0;
02785   return ctmpth;
02786 }
```

5.15.2.8 double ctmn2 (double *nu*, double *p*, double *t*)

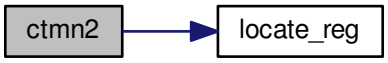
Compute nitrogen continuum (absorption coefficient).

Definition at line 2790 of file jurassic.c.

```
02793             {
02794
02795   static double ba[98] = { 0., 4.45e-8, 5.22e-8, 6.46e-8, 7.75e-8, 9.03e-8,
02796     1.06e-7, 1.21e-7, 1.37e-7, 1.57e-7, 1.75e-7, 2.01e-7, 2.3e-7,
02797     2.59e-7, 2.95e-7, 3.26e-7, 3.66e-7, 4.05e-7, 4.47e-7, 4.92e-7,
02798     5.34e-7, 5.84e-7, 6.24e-7, 6.67e-7, 7.14e-7, 7.26e-7, 7.54e-7,
02799     7.84e-7, 8.09e-7, 8.42e-7, 8.62e-7, 8.87e-7, 9.11e-7, 9.36e-7,
02800     9.76e-7, 1.03e-6, 1.11e-6, 1.23e-6, 1.39e-6, 1.61e-6, 1.76e-6,
02801     1.94e-6, 1.97e-6, 1.87e-6, 1.75e-6, 1.56e-6, 1.42e-6, 1.35e-6,
02802     1.32e-6, 1.29e-6, 1.29e-6, 1.29e-6, 1.3e-6, 1.32e-6, 1.33e-6,
02803     1.34e-6, 1.35e-6, 1.33e-6, 1.31e-6, 1.29e-6, 1.24e-6, 1.2e-6,
02804     1.16e-6, 1.1e-6, 1.04e-6, 9.96e-7, 9.38e-7, 8.63e-7, 7.98e-7,
02805     7.26e-7, 6.55e-7, 5.94e-7, 5.35e-7, 4.74e-7, 4.24e-7, 3.77e-7,
02806     3.33e-7, 2.96e-7, 2.63e-7, 2.34e-7, 2.08e-7, 1.85e-7, 1.67e-7,
02807     1.47e-7, 1.32e-7, 1.2e-7, 1.09e-7, 9.85e-8, 9.08e-8, 8.18e-8,
02808     7.56e-8, 6.85e-8, 6.14e-8, 5.83e-8, 5.77e-8, 5e-8, 4.32e-8, 0.
02809   };
02810
02811   static double betaa[98] = { 802., 802., 761., 722., 679., 646., 609., 562.,
02812     511., 472., 436., 406., 377., 355., 338., 319., 299., 278., 255.,
02813     233., 208., 184., 149., 107., 66., 25., -13., -49., -82., -104.,
02814     -119., -130., -139., -144., -146., -146., -147., -148., -150.,
02815     -153., -160., -169., -181., -189., -195., -200., -205., -209.,
02816     -211., -210., -210., -209., -205., -199., -190., -180., -168.,
02817     -157., -143., -126., -108., -89., -63., -32., 1., 35., 65., 95.,
02818     121., 141., 152., 161., 164., 164., 161., 155., 148., 143., 137.,
02819     133., 131., 133., 139., 150., 165., 187., 213., 248., 284., 321.,
02820     372., 449., 514., 569., 609., 642., 673., 673.
02821   };
02822
02823   static double nua[98] = { 2120., 2125., 2130., 2135., 2140., 2145., 2150.,
02824     2155., 2160., 2165., 2170., 2175., 2180., 2185., 2190., 2195.,
02825     2200., 2205., 2210., 2215., 2220., 2225., 2230., 2235., 2240.,
02826     2245., 2250., 2255., 2260., 2265., 2270., 2275., 2280., 2285.,
02827     2290., 2295., 2300., 2305., 2310., 2315., 2320., 2325., 2330.,
02828     2335., 2340., 2345., 2350., 2355., 2360., 2365., 2370., 2375.,
02829     2380., 2385., 2390., 2395., 2400., 2405., 2410., 2415., 2420.,
```

```
02830     2425., 2430., 2435., 2440., 2445., 2450., 2455., 2460., 2465.,
02831     2470., 2475., 2480., 2485., 2490., 2495., 2500., 2505., 2510.,
02832     2515., 2520., 2525., 2530., 2535., 2540., 2545., 2550., 2555.,
02833     2560., 2565., 2570., 2575., 2580., 2585., 2590., 2595., 2600., 2605.
02834   };
02835
02836   double b, beta, q_n2 = 0.79, t0 = 273, tr = 296;
02837
02838   int idx;
02839
02840   /* Check wavenumber range... */
02841   if (nu < nua[0] || nu > nua[97])
02842     return 0;
02843
02844   /* Interpolate B and beta... */
02845   idx = locate_reg(nua, 98, nu);
02846   b = LIN(nua[idx], ba[idx], nua[idx + 1], ba[idx + 1], nu);
02847   beta = LIN(nua[idx], betaa[idx], nua[idx + 1], betaa[idx + 1], nu);
02848
02849   /* Compute absorption coefficient... */
02850   return 0.1 * POW2(p / P0 * t0 / t) * exp(beta * (1 / tr - 1 / t))
02851     * q_n2 * b * (q_n2 + (1 - q_n2) * (1.294 - 0.4545 * t / tr));
02852 }
```

Here is the call graph for this function:



5.15.2.9 double ctmo2 (double *nu*, double *p*, double *t*)

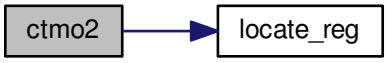
Compute oxygen continuum (absorption coefficient).

Definition at line 2856 of file jurassic.c.

```
02859             {
02860
02861   static double ba[90] = { 0., .061, .074, .084, .096, .12, .162, .208, .246,
02862     .285, .314, .38, .444, .5, .571, .673, .768, .853, .966, 1.097,
02863     1.214, 1.333, 1.466, 1.591, 1.693, 1.796, 1.922, 2.037, 2.154,
02864     2.264, 2.375, 2.508, 2.671, 2.847, 3.066, 3.417, 3.828, 4.204,
02865     4.453, 4.599, 4.528, 4.284, 3.955, 3.678, 3.477, 3.346, 3.29,
02866     3.251, 3.231, 3.226, 3.212, 3.192, 3.108, 3.033, 2.911, 2.798,
02867     2.646, 2.508, 2.322, 2.13, 1.928, 1.757, 1.588, 1.417, 1.253,
02868     1.109, .99, .888, .791, .678, .587, .524, .464, .403, .357, .32,
02869     .29, .267, .242, .215, .182, .16, .146, .128, .103, .087, .081,
02870     .071, .064, 0.
02871   };
02872
02873   static double betaa[90] = { 467., 467., 400., 315., 379., 368., 475., 521.,
02874     531., 512., 442., 444., 430., 381., 335., 324., 296., 248., 215.,
02875     193., 158., 127., 101., 71., 31., -6., -26., -47., -63., -79.,
02876     -88., -88., -87., -90., -98., -99., -109., -134., -160., -167.,
02877     -164., -158., -153., -151., -156., -166., -168., -173., -170.,
02878     -161., -145., -126., -108., -84., -59., -29., 4., 41., 73., 97.,
02879     123., 159., 198., 220., 242., 256., 281., 311., 334., 319., 313.,
02880     321., 323., 310., 315., 320., 335., 361., 378., 373., 338., 319.,
02881     346., 322., 291., 290., 350., 371., 504., 504.
02882   };
02883
02884   static double nua[90] = { 1360., 1365., 1370., 1375., 1380., 1385., 1390.,
02885     1395., 1400., 1405., 1410., 1415., 1420., 1425., 1430., 1435.,
02886     1440., 1445., 1450., 1455., 1460., 1465., 1470., 1475., 1480.,
02887     1485., 1490., 1495., 1500., 1505., 1510., 1515., 1520., 1525.,
02888     1530., 1535., 1540., 1545., 1550., 1555., 1560., 1565., 1570.,
```

```
02889     1575., 1580., 1585., 1590., 1595., 1600., 1605., 1610., 1615.,
02890     1620., 1625., 1630., 1635., 1640., 1645., 1650., 1655., 1660.,
02891     1665., 1670., 1675., 1680., 1685., 1690., 1695., 1700., 1705.,
02892     1710., 1715., 1720., 1725., 1730., 1735., 1740., 1745., 1750.,
02893     1755., 1760., 1765., 1770., 1775., 1780., 1785., 1790., 1795.,
02894     1800., 1805.
02895   };
02896
02897   double b, beta, q_o2 = 0.21, t0 = 273, tr = 296;
02898
02899   int idx;
02900
02901   /* Check wavenumber range... */
02902   if (nu < nua[0] || nu > nua[89])
02903     return 0;
02904
02905   /* Interpolate B and beta... */
02906   idx = locate_reg(nua, 90, nu);
02907   b = LIN(nua[idx], ba[idx], nua[idx + 1], ba[idx + 1], nu);
02908   beta = LIN(nua[idx], betaa[idx], nua[idx + 1], betaa[idx + 1], nu);
02909
02910   /* Compute absorption coefficient... */
02911   return 0.1 * POW2(p / P0 * t0 / t) * exp(beta * (1 / tr - 1 / t)) * q_o2 *
02912     b;
02913 }
```

Here is the call graph for this function:



5.15.2.10 void copy_atm (ctl_t * *ctl*, atm_t * *atm_dest*, atm_t * *atm_src*, int *init*)

Copy and initialize atmospheric data.

Definition at line 2917 of file jurassic.c.

```
02921             {
02922
02923   int ig, ip, iw;
02924
02925   size_t s;
02926
02927   /* Data size... */
02928   s = (size_t) atm_src->np * sizeof(double);
02929
02930   /* Copy data... */
02931   atm_dest->np = atm_src->np;
02932   memcpy(atm_dest->time, atm_src->time, s);
02933   memcpy(atm_dest->z, atm_src->z, s);
02934   memcpy(atm_dest->lon, atm_src->lon, s);
02935   memcpy(atm_dest->lat, atm_src->lat, s);
02936   memcpy(atm_dest->p, atm_src->p, s);
02937   memcpy(atm_dest->t, atm_src->t, s);
02938   for (ig = 0; ig < ctl->ng; ig++)
02939     memcpy(atm_dest->q[ig], atm_src->q[ig], s);
02940   for (iw = 0; iw < ctl->nw; iw++)
02941     memcpy(atm_dest->k[iw], atm_src->k[iw], s);
02942
02943   /* Initialize... */
02944   if (init)
02945     for (ip = 0; ip < atm_dest->np; ip++) {
02946       atm_dest->p[ip] = 0;
02947       atm_dest->t[ip] = 0;
02948       for (ig = 0; ig < ctl->ng; ig++)
02949         atm_dest->q[ig][ip] = 0;
02950       for (iw = 0; iw < ctl->nw; iw++)
02951         atm_dest->k[iw][ip] = 0;
02952     }
02953 }
```

5.15.2.11 void copy_obs (ctl_t * *ctl*, obs_t * *obs_dest*, obs_t * *obs_src*, int *init*)

Copy and initialize observation data.

Definition at line 2957 of file jurassic.c.

```
02961             {
02962
02963   int id, ir;
02964
02965   size_t s;
02966
02967   /* Data size... */
02968   s = (size_t) obs_src->nr * sizeof(double);
02969
02970   /* Copy data... */
02971   obs_dest->nr = obs_src->nr;
02972   memcpy(obs_dest->time, obs_src->time, s);
02973   memcpy(obs_dest->obsz, obs_src->obsz, s);
02974   memcpy(obs_dest->obslon, obs_src->obslon, s);
02975   memcpy(obs_dest->obslat, obs_src->obslat, s);
02976   memcpy(obs_dest->vpz, obs_src->vpz, s);
02977   memcpy(obs_dest->vplon, obs_src->vplon, s);
02978   memcpy(obs_dest->vplat, obs_src->vplat, s);
02979   memcpy(obs_dest->tpz, obs_src->tpz, s);
02980   memcpy(obs_dest->tplon, obs_src->tplon, s);
02981   memcpy(obs_dest->tplat, obs_src->tplat, s);
02982   for (id = 0; id < ctl->nd; id++)
02983     memcpy(obs_dest->rad[id], obs_src->rad[id], s);
02984   for (id = 0; id < ctl->nd; id++)
02985     memcpy(obs_dest->tau[id], obs_src->tau[id], s);
02986
02987   /* Initialize... */
02988   if (init)
02989     for (id = 0; id < ctl->nd; id++)
02990       for (ir = 0; ir < obs_dest->nr; ir++)
02991         if (gsl_finite(obs_dest->rad[id][ir])) {
02992           obs_dest->rad[id][ir] = 0;
02993           obs_dest->tau[id][ir] = 0;
02994         }
02995 }
```

5.15.2.12 int find_emitter (ctl_t * *ctl*, const char * *emitter*)

Find index of an emitter.

Definition at line 2999 of file jurassic.c.

```
03001                         {
03002
03003   int ig;
03004
03005   for (ig = 0; ig < ctl->ng; ig++)
03006     if (strcasecmp(ctl->emitter[ig], emitter) == 0)
03007       return ig;
03008
03009   return -1;
03010 }
```

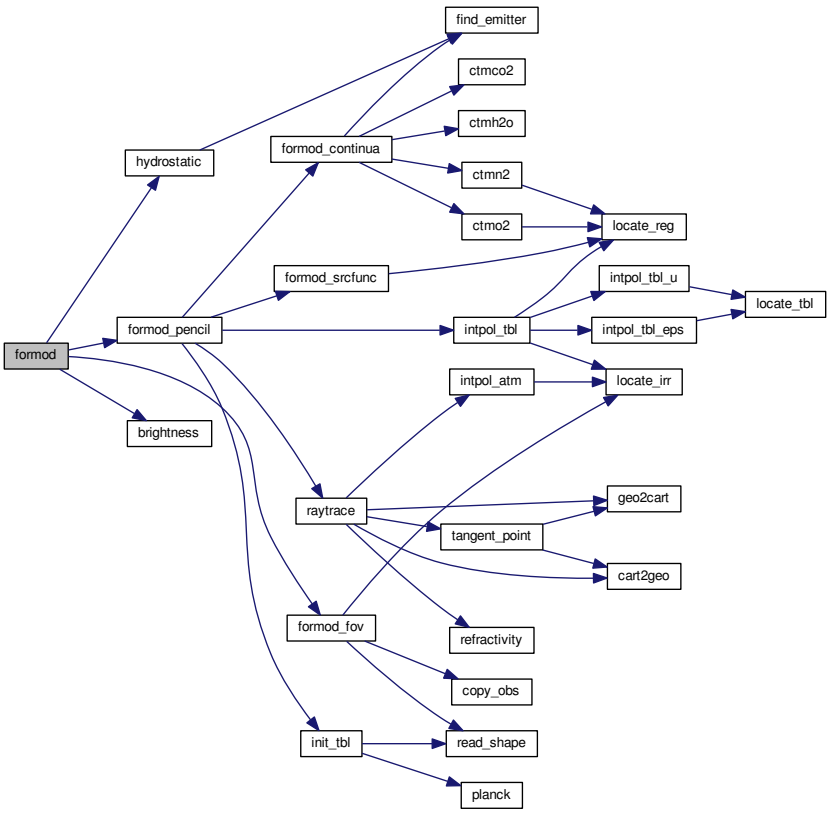
5.15.2.13 void formod (ctl_t * *ctl*, atm_t * *atm*, obs_t * *obs*)

Determine ray paths and compute radiative transfer.

Definition at line 3014 of file jurassic.c.

```
03017                {
03018
03019   int id, ir, *mask;
03020
03021   /* Allocate... */
03022   ALLOC(mask, int,
03023         ND * NR);
03024
03025   /* Save observation mask... */
03026   for (id = 0; id < ctl->nd; id++)
03027     for (ir = 0; ir < obs->nr; ir++)
03028       mask[id * NR + ir] = !gsl_finite(obs->rad[id][ir]);
03029
03030   /* Hydrostatic equilibrium... */
03031   hydrostatic(ctl, atm);
03032
03033   /* Calculate pencil beams... */
03034   for (ir = 0; ir < obs->nr; ir++)
03035     formod_pencil(ctl, atm, obs, ir);
03036
03037   /* Apply field-of-view convolution... */
03038   formod_fov(ctl, obs);
03039
03040   /* Convert radiance to brightness temperature... */
03041   if (ctl->write_bbt)
03042     for (id = 0; id < ctl->nd; id++)
03043       for (ir = 0; ir < obs->nr; ir++)
03044         obs->rad[id][ir] = brightness(obs->rad[id][ir], ctl->nu[id]);
03045
03046   /* Apply observation mask... */
03047   for (id = 0; id < ctl->nd; id++)
03048     for (ir = 0; ir < obs->nr; ir++)
03049       if (mask[id * NR + ir])
03050         obs->rad[id][ir] = GSL_NAN;
03051
03052   /* Free... */
03053   free(mask);
03054 }
```

Here is the call graph for this function:



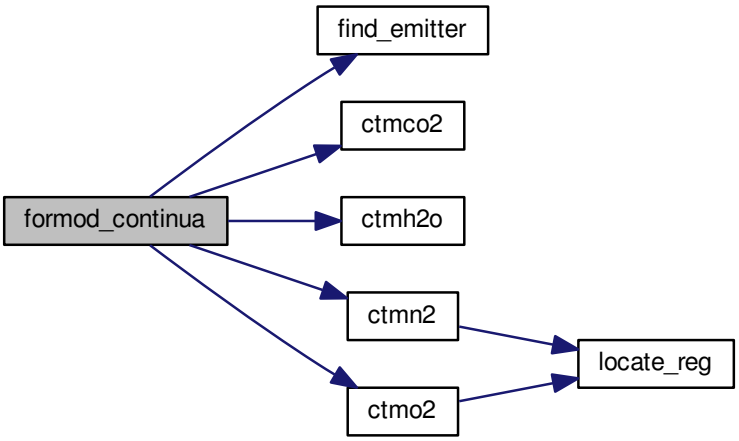
5.15.2.14 void formod_continua (ctl_t * *ctl*, los_t * *los*, int *ip*, double * *beta*)

Compute absorption coefficient of continua.

Definition at line 3058 of file jurassic.c.

```
03062                {
03063
03064   static int ig_co2 = -999, ig_h2o = -999;
03065
03066   int id;
03067
03068   /* Extinction... */
03069   for (id = 0; id < ctl->nd; id++)
03070     beta[id] = los->k[ctl->window[id]][ip];
03071
03072   /* CO2 continuum... */
03073   if (ctl->ctm_co2) {
03074     if (ig_co2 == -999)
03075       ig_co2 = find_emitter(ctl, "CO2");
03076     if (ig_co2 >= 0)
03077       for (id = 0; id < ctl->nd; id++)
03078         beta[id] += ctmco2(ctl->nu[id], los->p[ip], los->t[ip],
03079                            los->u[ig_co2][ip]) / los->ds[ip];
03080   }
03081
03082   /* H2O continuum... */
03083   if (ctl->ctm_h2o) {
03084     if (ig_h2o == -999)
03085       ig_h2o = find_emitter(ctl, "H2O");
03086     if (ig_h2o >= 0)
03087       for (id = 0; id < ctl->nd; id++)
03088         beta[id] += ctmh2o(ctl->nu[id], los->p[ip], los->t[ip],
03089                            los->q[ig_h2o][ip],
03090                            los->u[ig_h2o][ip]) / los->ds[ip];
03091   }
03092
03093   /* N2 continuum... */
03094   if (ctl->ctm_n2)
03095     for (id = 0; id < ctl->nd; id++)
03096       beta[id] += ctmn2(ctl->nu[id], los->p[ip], los->t[ip]);
03097
03098   /* O2 continuum... */
03099   if (ctl->ctm_o2)
03100     for (id = 0; id < ctl->nd; id++)
03101       beta[id] += ctmo2(ctl->nu[id], los->p[ip], los->t[ip]);
03102 }
```

Here is the call graph for this function:



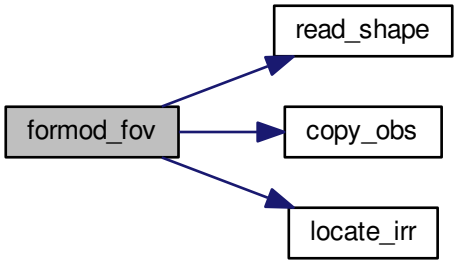
5.15.2.15 void formod_fov (ctl_t * *ctl*, obs_t * *obs*)

Apply field of view convolution.

Definition at line 3106 of file jurassic.c.

```
03108                {
03109
03110   static double dz[NSHAPE], w[NSHAPE];
03111
03112   static int init = 0, n;
03113
03114   obs_t *obs2;
03115
03116   double rad[ND][NR], tau[ND][NR], wsum, z[NR], zfov;
03117
03118   int i, id, idx, ir, ir2, nz;
03119
03120   /* Do not take into account FOV... */
03121   if (ctl->fov[0] == '-')
03122     return;
03123
03124   /* Initialize FOV data... */
03125   if (!init) {
03126     init = 1;
03127     read_shape(ctl->fov, dz, w, &n);
03128   }
03129
03130   /* Allocate... */
03131   ALLOC(obs2, obs_t, 1);
03132
03133   /* Copy observation data... */
03134   copy_obs(ctl, obs2, obs, 0);
03135
03136   /* Loop over ray paths... */
03137   for (ir = 0; ir < obs->nr; ir++) {
03138
03139     /* Get radiance and transmittance profiles... */
03140     nz = 0;
03141     for (ir2 = GSL_MAX(ir - NFOV, 0); ir2 < GSL_MIN(ir + 1 + NFOV, obs->nr);
03142          ir2++)
03143       if (obs->time[ir2] == obs->time[ir]) {
03144         z[nz] = obs2->vpz[ir2];
03145         for (id = 0; id < ctl->nd; id++) {
03146           rad[id][nz] = obs2->rad[id][ir2];
03147           tau[id][nz] = obs2->tau[id][ir2];
03148         }
03149         nz++;
03150       }
03151     if (nz < 2)
03152       ERRMSG("Cannot apply FOV convolution!");
03153
03154     /* Convolute profiles with FOV... */
03155     wsum = 0;
03156     for (id = 0; id < ctl->nd; id++) {
03157       obs->rad[id][ir] = 0;
03158       obs->tau[id][ir] = 0;
03159     }
03160     for (i = 0; i < n; i++) {
03161       zfov = obs->vpz[ir] + dz[i];
03162       idx = locate_irr(z, nz, zfov);
03163       for (id = 0; id < ctl->nd; id++) {
03164         obs->rad[id][ir] += w[i]
03165           * LIN(z[idx], rad[id][idx], z[idx + 1], rad[id][idx + 1], zfov);
03166         obs->tau[id][ir] += w[i]
03167           * LIN(z[idx], tau[id][idx], z[idx + 1], tau[id][idx + 1], zfov);
03168       }
03169       wsum += w[i];
03170     }
03171     for (id = 0; id < ctl->nd; id++) {
03172       obs->rad[id][ir] /= wsum;
03173       obs->tau[id][ir] /= wsum;
03174     }
03175   }
03176
03177   /* Free... */
03178   free(obs2);
03179 }
```

Here is the call graph for this function:



5.15.2.16 void formod_pencil (ctl_t * *ctl*, atm_t * *atm*, obs_t * *obs*, int *ir*)

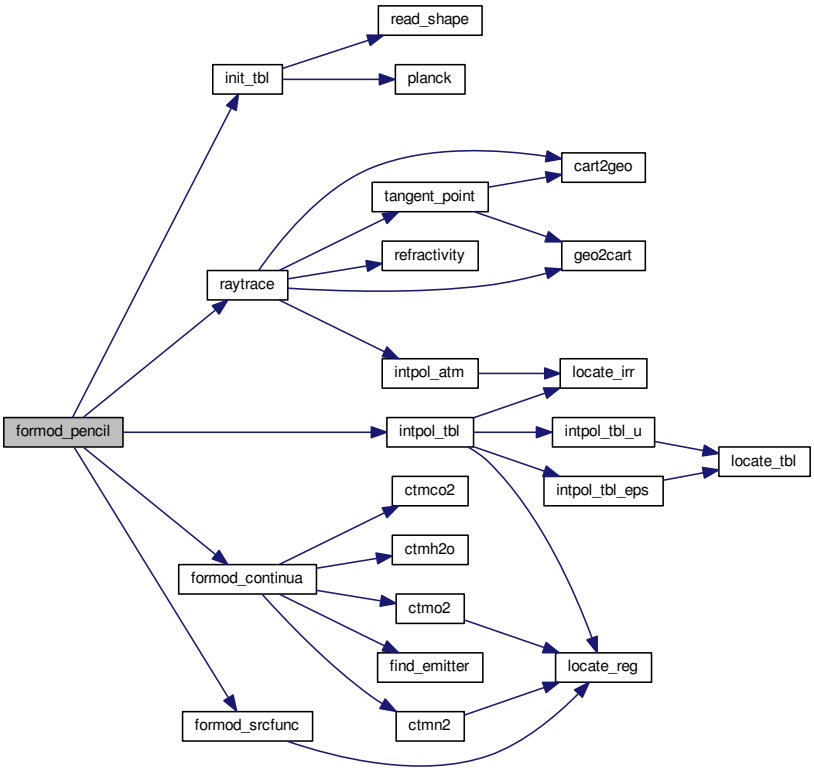
Compute radiative transfer for a pencil beam.

Definition at line 3183 of file jurassic.c.

```
03187           {
03188
03189     static tbl_t *tbl;
03190
03191     static int init = 0;
03192
03193     los_t *los;
03194
03195     double beta_ctm[ND], eps, src_planck[ND], tau_path[NG][ND], tau_gas[ND];
03196
03197     int id, ip;
03198
03199     /* Initialize look-up tables... */
03200     if (!init) {
03201       init = 1;
03202       ALLOC(tbl, tbl_t, 1);
03203       init_tbl(ctl, tbl);
03204     }
03205
03206     /* Allocate... */
03207     ALLOC(los, los_t, 1);
03208
03209     /* Initialize... */
03210     for (id = 0; id < ctl->nd; id++) {
03211       obs->rad[id][ir] = 0;
03212       obs->tau[id][ir] = 1;
03213     }
03214
03215     /* Raytracing... */
03216     raytrace(ctl, atm, obs, los, ir);
03217
03218     /* Loop over LOS points... */
03219     for (ip = 0; ip < los->np; ip++) {
03220
03221       /* Get trace gas transmittance... */
03222       intpol_tbl(ctl, tbl, los, ip, tau_path, tau_gas);
03223
03224       /* Get continuum absorption... */
03225       formod_continua(ctl, los, ip, beta_ctm);
03226
03227       /* Compute Planck function... */
03228       formod_srcfunc(ctl, tbl, los->t[ip], src_planck);
03229
03230       /* Loop over channels... */
03231       for (id = 0; id < ctl->nd; id++)
03232         if (tau_gas[id] > 0) {
03233
```

```
03234         /* Get segment emissivity... */
03235         eps = 1 - tau_gas[id] * exp(-beta_ctm[id] * los->ds[ip]);
03236
03237         /* Compute radiance... */
03238         obs->rad[id][ir] += src_planck[id] * eps * obs->tau[id][ir];
03239
03240         /* Compute path transmittance... */
03241         obs->tau[id][ir] *= (1 - eps);
03242       }
03243   }
03244
03245   /* Add surface... */
03246   if (los->tsurf > 0) {
03247     formod_srcfunc(ctl, tbl, los->tsurf, src_planck);
03248     for (id = 0; id < ctl->nd; id++)
03249       obs->rad[id][ir] += src_planck[id] * obs->tau[id][ir];
03250   }
03251
03252   /* Free... */
03253   free(los);
03254 }
```

Here is the call graph for this function:



5.15.2.17 void formod_srcfunc (ctl_t * *ctl*, tbl_t * *tbl*, double *t*, double * *src*)

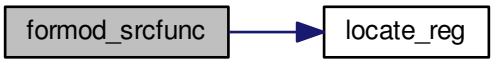
Compute Planck source function.

Definition at line 3258 of file jurassic.c.

```
03262                 {
03263
03264   int id, it;
```

```
03265
03266   /* Determine index in temperature array... */
03267   it = locate_reg(tbl->st, TBLNS, t);
03268
03269   /* Interpolate Planck function value... */
03270   for (id = 0; id < ctl->nd; id++)
03271     src[id] = LIN(tbl->st[it], tbl->sr[id][it],
03272                   tbl->st[it + 1], tbl->sr[id][it + 1], t);
03273 }
```

Here is the call graph for this function:



5.15.2.18 void geo2cart (double *z*, double *lon*, double *lat*, double * *x*)

Convert geolocation to Cartesian coordinates.

Definition at line 3277 of file jurassic.c.

```
03281             {
03282
03283   double radius;
03284
03285   radius = z + RE;
03286   x[0] = radius * cos(lat / 180 * M_PI) * cos(lon / 180 * M_PI);
03287   x[1] = radius * cos(lat / 180 * M_PI) * sin(lon / 180 * M_PI);
03288   x[2] = radius * sin(lat / 180 * M_PI);
03289 }
```

5.15.2.19 void hydrostatic (ctl_t * *ctl*, atm_t * *atm*)

Set hydrostatic equilibrium.

Definition at line 3293 of file jurassic.c.

```
03295               {
03296
03297   static int ig_h2o = -999;
03298
03299   double dzmin = 1e99, e = 0, mean, mmair = 28.96456e-3, mmh2o = 18.0153e-3;
03300
03301   int i, ip, ipref = 0, ipts = 20;
03302
03303   /* Check reference height... */
03304   if (ctl->hydz < 0)
03305     return;
03306
03307   /* Determine emitter index of H2O... */
03308   if (ig_h2o == -999)
03309     ig_h2o = find_emitter(ctl, "H2O");
03310
03311   /* Find air parcel next to reference height... */
03312   for (ip = 0; ip < atm->np; ip++)
03313     if (fabs(atm->z[ip] - ctl->hydz) < dzmin) {
03314       dzmin = fabs(atm->z[ip] - ctl->hydz);
03315       ipref = ip;
03316     }
```

```
03317
03318   /* Upper part of profile... */
03319   for (ip = ipref + 1; ip < atm->np; ip++) {
03320     mean = 0;
03321     for (i = 0; i < ipts; i++) {
03322       if (ig_h2o >= 0)
03323         e = LIN(0.0, atm->q[ig_h2o][ip - 1],
03324                 ipts - 1.0, atm->q[ig_h2o][ip], (double) i);
03325       mean += (e * mmh2o + (1 - e) * mmair)
03326         * G0 / RI
03327         / LIN(0.0, atm->t[ip - 1], ipts - 1.0, atm->t[ip], (double) i) / ipts;
03328     }
03329
03330     /* Compute p(z,T)... */
03331     atm->p[ip] =
03332       exp(log(atm->p[ip - 1]) - mean * 1000 * (atm->z[ip] - atm->z[ip - 1]));
03333   }
03334
03335   /* Lower part of profile... */
03336   for (ip = ipref - 1; ip >= 0; ip--) {
03337     mean = 0;
03338     for (i = 0; i < ipts; i++) {
03339       if (ig_h2o >= 0)
03340         e = LIN(0.0, atm->q[ig_h2o][ip + 1],
03341                 ipts - 1.0, atm->q[ig_h2o][ip], (double) i);
03342       mean += (e * mmh2o + (1 - e) * mmair)
03343         * G0 / RI
03344         / LIN(0.0, atm->t[ip + 1], ipts - 1.0, atm->t[ip], (double) i) / ipts;
03345     }
03346
03347     /* Compute p(z,T)... */
03348     atm->p[ip] =
03349       exp(log(atm->p[ip + 1]) - mean * 1000 * (atm->z[ip] - atm->z[ip + 1]));
03350   }
03351 }
```

Here is the call graph for this function:

5.15.2.20 void idx2name (ctl_t * *ctl*, int *idx*, char * *quantity*)

Determine name of state vector quantity for given index.

Definition at line 3355 of file jurassic.c.

```
03358                   {
03359
03360   int ig, iw;
03361
03362   if (idx == IDXP)
03363     sprintf(quantity, "PRESSURE");
03364
03365   if (idx == IDXT)
03366     sprintf(quantity, "TEMPERATURE");
03367
03368   for (ig = 0; ig < ctl->ng; ig++)
03369     if (idx == IDXQ(ig))
03370       sprintf(quantity, "%s", ctl->emitter[ig]);
03371
03372   for (iw = 0; iw < ctl->nw; iw++)
03373     if (idx == IDXK(iw))
03374       sprintf(quantity, "EXTINCT_WINDOW%d", iw);
03375 }
```

5.15.2.21 void init_tbl (ctl_t * *ctl*, tbl_t * *tbl*)

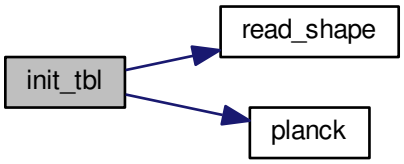
Initialize look-up tables.

Definition at line 3379 of file jurassic.c.

```
03381               {
03382
03383   FILE *in;
03384
03385   char filename[2 * LEN], line[LEN];
03386
03387   double eps, eps_old, press, press_old, temp, temp_old, u, u_old,
03388     f[NSHAPE], fsum, nu[NSHAPE];
03389
03390   int i, id, ig, ip, it, n;
03391
03392   /* Loop over trace gases and channels... */
03393   for (ig = 0; ig < ctl->ng; ig++)
03394 #pragma omp parallel for default(none) shared(ctl,tbl,ig) private(in,filename,line,eps,eps_old,press,
      press_old,temp,temp_old,u,u_old,id,ip,it)
03395     for (id = 0; id < ctl->nd; id++) {
03396
03397       /* Initialize... */
03398       tbl->np[ig][id] = -1;
03399       eps_old = -999;
03400       press_old = -999;
03401       temp_old = -999;
03402       u_old = -999;
03403
03404       /* Try to open file... */
03405       sprintf(filename, "%s_%.4f_%s.tab",
03406               ctl->tblbase, ctl->nu[id], ctl->emitter[ig]);
03407       if (!(in = fopen(filename, "r"))) {
03408         printf("Missing emissivity table: %s\n", filename);
03409         continue;
03410       }
03411       printf("Read emissivity table: %s\n", filename);
03412
03413       /* Read data... */
03414       while (fgets(line, LEN, in)) {
03415
03416         /* Parse line... */
03417         if (sscanf(line, "%lg %lg %lg %lg", &press, &temp, &u, &eps) != 4)
03418           continue;
03419
03420         /* Determine pressure index... */
03421         if (press != press_old) {
03422           press_old = press;
03423           if ((++tbl->np[ig][id]) >= TBLNP)
03424             ERRMSG("Too many pressure levels!");
03425           tbl->nt[ig][id][tbl->np[ig][id]] = -1;
03426         }
03427
03428         /* Determine temperature index... */
03429         if (temp != temp_old) {
03430           temp_old = temp;
03431           if ((++tbl->nt[ig][id][tbl->np[ig][id]]) >= TBLNT)
03432             ERRMSG("Too many temperatures!");
03433           tbl->nu[ig][id][tbl->np[ig][id]]
03434             [tbl->nt[ig][id][tbl->np[ig][id]]] = -1;
03435         }
03436
03437         /* Determine column density index... */
03438         if ((eps > eps_old && u > u_old) || tbl->nu[ig][id][tbl->np[ig][id]]
03439             [tbl->nt[ig][id][tbl->np[ig][id]]] < 0) {
03440           eps_old = eps;
03441           u_old = u;
03442           if ((++tbl->nu[ig][id][tbl->np[ig][id]]
03443                [tbl->nt[ig][id][tbl->np[ig][id]]]) >= TBLNU) {
03444             tbl->nu[ig][id][tbl->np[ig][id]]
03445               [tbl->nt[ig][id][tbl->np[ig][id]]]--;
03446             continue;
03447           }
03448         }
03449
03450         /* Store data... */
03451         tbl->p[ig][id][tbl->np[ig][id]] = press;
03452         tbl->t[ig][id][tbl->np[ig][id]][tbl->nt[ig][id][tbl->np[ig][id]]]
03453           = temp;
03454         tbl->u[ig][id][tbl->np[ig][id]][tbl->nt[ig][id][tbl->np[ig][id]]]
03455           [tbl->nu[ig][id][tbl->np[ig][id]]
03456            [tbl->nt[ig][id][tbl->np[ig][id]]]] = (float) u;
```

```
03457         tbl->eps[ig][id][tbl->np[ig][id]][tbl->nt[ig][id][tbl->np[ig][id]]]
03458           [tbl->nu[ig][id][tbl->np[ig][id]]
03459            [tbl->nt[ig][id][tbl->np[ig][id]]]] = (float) eps;
03460       }
03461
03462       /* Increment counters... */
03463       tbl->np[ig][id]++;
03464       for (ip = 0; ip < tbl->np[ig][id]; ip++) {
03465         tbl->nt[ig][id][ip]++;
03466         for (it = 0; it < tbl->nt[ig][id][ip]; it++)
03467           tbl->nu[ig][id][ip][it]++;
03468       }
03469
03470       /* Close file... */
03471       fclose(in);
03472     }
03473
03474   /* Write info... */
03475   printf("Initialize source function table...\n");
03476
03477   /* Loop over channels... */
03478 #pragma omp parallel for default(none) shared(ctl,tbl,ig) private(filename,it,i,n,f,fsum,nu)
03479   for (id = 0; id < ctl->nd; id++) {
03480
03481     /* Read filter function... */
03482     sprintf(filename, "%s_%.4f.filt", ctl->tblbase, ctl->nu[id]);
03483     read_shape(filename, nu, f, &n);
03484
03485     /* Compute source function table... */
03486     for (it = 0; it < TBLNS; it++) {
03487
03488       /* Set temperature... */
03489       tbl->st[it] = LIN(0.0, TMIN, TBLNS - 1.0, TMAX, (double) it);
03490
03491       /* Integrate Planck function... */
03492       fsum = 0;
03493       tbl->sr[id][it] = 0;
03494       for (i = 0; i < n; i++) {
03495         fsum += f[i];
03496         tbl->sr[id][it] += f[i] * planck(tbl->st[it], nu[i]);
03497       }
03498       tbl->sr[id][it] /= fsum;
03499     }
03500   }
03501 }
```

Here is the call graph for this function:



5.15.2.22 void intpol_atm (ctl_t * *ctl*, atm_t * *atm*, double *z*, double * *p*, double * *t*, double * *q*, double * *k*)

Interpolate atmospheric data.

Definition at line 3505 of file jurassic.c.

```
03512              {
03513
03514   int ig, ip, iw;
03515
```

```
03516   /* Get array index... */
03517   ip = locate_irr(atm->z, atm->np, z);
03518
03519   /* Interpolate... */
03520   *p = EXP(atm->z[ip], atm->p[ip], atm->z[ip + 1], atm->p[ip + 1], z);
03521   *t = LIN(atm->z[ip], atm->t[ip], atm->z[ip + 1], atm->t[ip + 1], z);
03522   for (ig = 0; ig < ctl->ng; ig++)
03523     q[ig] =
03524       LIN(atm->z[ip], atm->q[ig][ip], atm->z[ip + 1], atm->q[ig][ip + 1], z);
03525   for (iw = 0; iw < ctl->nw; iw++)
03526     k[iw] =
03527       LIN(atm->z[ip], atm->k[iw][ip], atm->z[ip + 1], atm->k[iw][ip + 1], z);
03528 }
```

Here is the call graph for this function:

5.15.2.23 void intpol_tbl (ctl_t * *ctl*, tbl_t * *tbl*, los_t * *los*, int *ip*, double *tau_path[NG][ND]*, double *tau_seg[ND]*)

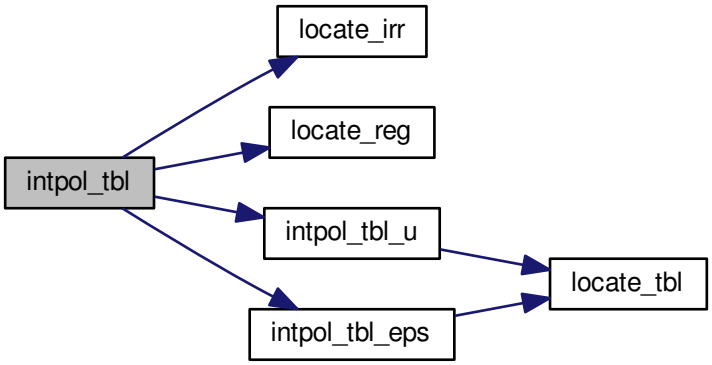
Get transmittance from look-up tables.

Definition at line 3532 of file jurassic.c.

```
03538                       {
03539
03540   double eps, eps00, eps01, eps10, eps11, u;
03541
03542   int id, ig, ipr, it0, it1;
03543
03544   /* Initialize... */
03545   if (ip <= 0)
03546     for (ig = 0; ig < ctl->ng; ig++)
03547       for (id = 0; id < ctl->nd; id++)
03548         tau_path[ig][id] = 1;
03549
03550   /* Loop over channels... */
03551   for (id = 0; id < ctl->nd; id++) {
03552
03553     /* Initialize... */
03554     tau_seg[id] = 1;
03555
03556     /* Loop over emitters.... */
03557     for (ig = 0; ig < ctl->ng; ig++) {
03558
03559       /* Check size of table (pressure)... */
03560       if (tbl->np[ig][id] < 2)
03561         eps = 0;
03562
03563       /* Check transmittance... */
03564       else if (tau_path[ig][id] < 1e-9)
03565         eps = 1;
03566
03567       /* Interpolate... */
03568       else {
03569
03570         /* Determine pressure and temperature indices... */
03571         ipr = locate_irr(tbl->p[ig][id], tbl->np[ig][id], los->p[ip]);
03572         it0 =
03573           locate_irr(tbl->t[ig][id][ipr], tbl->nt[ig][id][ipr], los->
    t[ip]);
03574         it1 =
03575           locate_reg(tbl->t[ig][id][ipr + 1], tbl->nt[ig][id][ipr + 1],
03576                      los->t[ip]);
```

```
03577
03578         /* Check size of table (temperature and column density)... */
03579         if (tbl->nt[ig][id][ipr] < 2 || tbl->nt[ig][id][ipr + 1] < 2
03580             || tbl->nu[ig][id][ipr][it0] < 2
03581             || tbl->nu[ig][id][ipr][it0 + 1] < 2
03582             || tbl->nu[ig][id][ipr + 1][it1] < 2
03583             || tbl->nu[ig][id][ipr + 1][it1 + 1] < 2)
03584           eps = 0;
03585
03586         else {
03587
03588           /* Get emissivities of extended path... */
03589           u = intpol_tbl_u(tbl, ig, id, ipr, it0, 1 - tau_path[ig][id]);
03590           eps00 = intpol_tbl_eps(tbl, ig, id, ipr, it0, u + los->u[ig][ip]);
03591
03592           u = intpol_tbl_u(tbl, ig, id, ipr, it0 + 1, 1 - tau_path[ig][id]);
03593           eps01 =
03594             intpol_tbl_eps(tbl, ig, id, ipr, it0 + 1, u + los->u[ig][ip]);
03595
03596           u = intpol_tbl_u(tbl, ig, id, ipr + 1, it1, 1 - tau_path[ig][id]);
03597           eps10 =
03598             intpol_tbl_eps(tbl, ig, id, ipr + 1, it1, u + los->u[ig][ip]);
03599
03600           u =
03601             intpol_tbl_u(tbl, ig, id, ipr + 1, it1 + 1, 1 - tau_path[ig][id]);
03602           eps11 =
03603             intpol_tbl_eps(tbl, ig, id, ipr + 1, it1 + 1, u + los->
    u[ig][ip]);
03604
03605           /* Interpolate with respect to temperature... */
03606           eps00 = LIN(tbl->t[ig][id][ipr][it0], eps00,
03607                       tbl->t[ig][id][ipr][it0 + 1], eps01, los->t[ip]);
03608           eps11 = LIN(tbl->t[ig][id][ipr + 1][it1], eps10,
03609                       tbl->t[ig][id][ipr + 1][it1 + 1], eps11, los->t[ip]);
03610
03611           /* Interpolate with respect to pressure... */
03612           eps00 = LIN(tbl->p[ig][id][ipr], eps00,
03613                       tbl->p[ig][id][ipr + 1], eps11, los->p[ip]);
03614
03615           /* Check emssivity range... */
03616           eps00 = GSL_MAX(GSL_MIN(eps00, 1), 0);
03617
03618           /* Determine segment emissivity... */
03619           eps = 1 - (1 - eps00) / tau_path[ig][id];
03620         }
03621       }
03622
03623       /* Get transmittance of extended path... */
03624       tau_path[ig][id] *= (1 - eps);
03625
03626       /* Get segment transmittance... */
03627       tau_seg[id] *= (1 - eps);
03628     }
03629   }
03630 }
```

Here is the call graph for this function:



5.15.2.24 double intpol_tbl_eps (tbl_t * *tbl*, int *ig*, int *id*, int *ip*, int *it*, double *u*)

Interpolate emissivity from look-up tables.

Definition at line 3634 of file jurassic.c.

```
03640             {
03641
03642   int idx;
03643
03644   /* Lower boundary... */
03645   if (u < tbl->u[ig][id][ip][it][0])
03646     return LIN(0, 0, tbl->u[ig][id][ip][it][0], tbl->eps[ig][id][ip][it][0],
03647                u);
03648
03649   /* Upper boundary... */
03650   else if (u > tbl->u[ig][id][ip][it][tbl->nu[ig][id][ip][it] - 1])
03651     return LIN(tbl->u[ig][id][ip][it][tbl->nu[ig][id][ip][it] - 1],
03652                tbl->eps[ig][id][ip][it][tbl->nu[ig][id][ip][it] - 1],
03653                1e30, 1, u);
03654
03655   /* Interpolation... */
03656   else {
03657
03658     /* Get index... */
03659     idx = locate_tbl(tbl->u[ig][id][ip][it], tbl->nu[ig][id][ip][it], u);
03660
03661     /* Interpolate... */
03662     return
03663       LIN(tbl->u[ig][id][ip][it][idx], tbl->eps[ig][id][ip][it][idx],
03664           tbl->u[ig][id][ip][it][idx + 1], tbl->eps[ig][id][ip][it][idx + 1],
03665           u);
03666   }
03667 }
```

Here is the call graph for this function:

5.15.2.25 double intpol_tbl_u (tbl_t * *tbl*, int *ig*, int *id*, int *ip*, int *it*, double *eps*)

Interpolate column density from look-up tables.

Definition at line 3671 of file jurassic.c.

```
03677             {
03678
03679   int idx;
03680
03681   /* Lower boundary... */
03682   if (eps < tbl->eps[ig][id][ip][it][0])
03683     return LIN(0, 0, tbl->eps[ig][id][ip][it][0], tbl->u[ig][id][ip][it][0],
03684                eps);
03685
03686   /* Upper boundary... */
03687   else if (eps > tbl->eps[ig][id][ip][it][tbl->nu[ig][id][ip][it] - 1])
03688     return LIN(tbl->eps[ig][id][ip][it][tbl->nu[ig][id][ip][it] - 1],
03689                tbl->u[ig][id][ip][it][tbl->nu[ig][id][ip][it] - 1],
03690                1, 1e30, eps);
03691
```

```
03692   /* Interpolation... */
03693   else {
03694
03695     /* Get index... */
03696     idx = locate_tbl(tbl->eps[ig][id][ip][it], tbl->nu[ig][id][ip][it], eps);
03697
03698     /* Interpolate... */
03699     return
03700       LIN(tbl->eps[ig][id][ip][it][idx], tbl->u[ig][id][ip][it][idx],
03701           tbl->eps[ig][id][ip][it][idx + 1], tbl->u[ig][id][ip][it][idx + 1],
03702           eps);
03703   }
03704 }
```

Here is the call graph for this function:

5.15.2.26 void jsec2time (double *jsec*, int * *year*, int * *mon*, int * *day*, int * *hour*, int * *min*, int * *sec*, double * *remain*)

Convert seconds to date.

Definition at line 3708 of file jurassic.c.

```
03716                   {
03717
03718   struct tm t0, *t1;
03719
03720   time_t jsec0;
03721
03722   t0.tm_year = 100;
03723   t0.tm_mon = 0;
03724   t0.tm_mday = 1;
03725   t0.tm_hour = 0;
03726   t0.tm_min = 0;
03727   t0.tm_sec = 0;
03728
03729   jsec0 = (time_t) jsec + timegm(&t0);
03730   t1 = gmtime(&jsec0);
03731
03732   *year = t1->tm_year + 1900;
03733   *mon = t1->tm_mon + 1;
03734   *day = t1->tm_mday;
03735   *hour = t1->tm_hour;
03736   *min = t1->tm_min;
03737   *sec = t1->tm_sec;
03738   *remain = jsec - floor(jsec);
03739 }
```

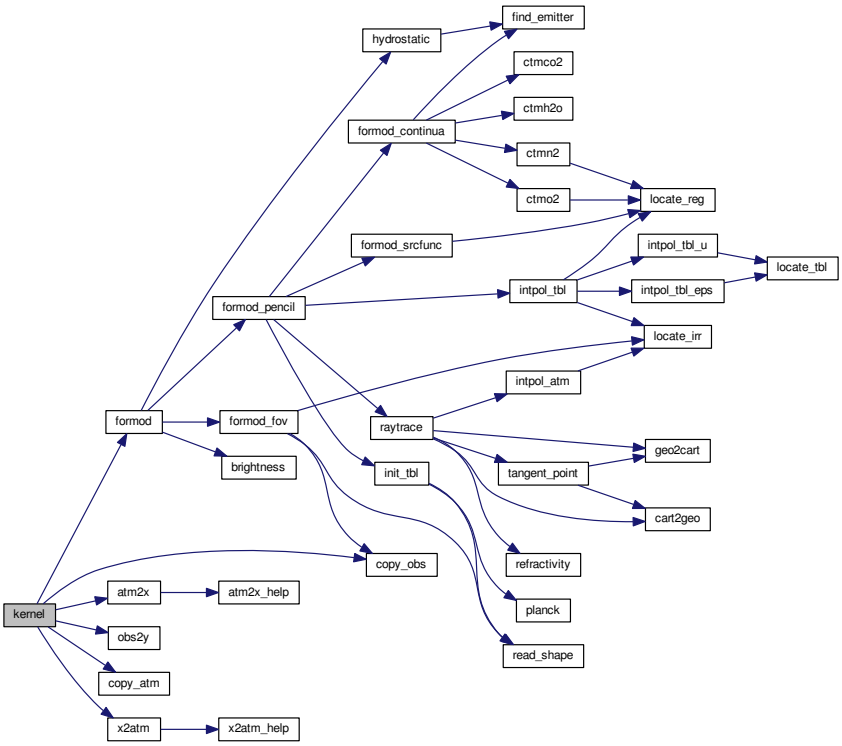
5.15.2.27 void kernel (ctl_t * *ctl*, atm_t * *atm*, obs_t * *obs*, gsl_matrix * *k*)

Compute Jacobians.

Definition at line 3743 of file jurassic.c.

```
03747                   {
03748
03749   atm_t *atm1;
03750   obs_t *obs1;
03751
03752   gsl_vector *x0, *x1, *yy0, *yy1;
03753
03754   int *iqa, j;
03755
03756   double h;
03757
03758   size_t i, n, m;
03759
03760   /* Get sizes... */
03761   m = k->size1;
03762   n = k->size2;
03763
03764   /* Allocate... */
03765   x0 = gsl_vector_alloc(n);
03766   yy0 = gsl_vector_alloc(m);
03767   ALLOC(iqa, int,
03768         N);
03769
03770   /* Compute radiance for undisturbed atmospheric data... */
03771   formod(ctl, atm, obs);
03772
03773   /* Compose vectors... */
03774   atm2x(ctl, atm, x0, iqa, NULL);
03775   obs2y(ctl, obs, yy0, NULL, NULL);
03776
03777   /* Initialize kernel matrix... */
03778   gsl_matrix_set_zero(k);
03779
03780   /* Loop over state vector elements... */
03781 #pragma omp parallel for default(none) shared(ctl,atm,obs,k,x0,yy0,n,m,iqa) private(i, j, h, x1, yy1, atm1,
      obs1)
03782   for (j = 0; j < (int) n; j++) {
03783
03784     /* Allocate... */
03785     x1 = gsl_vector_alloc(n);
03786     yy1 = gsl_vector_alloc(m);
03787     ALLOC(atm1, atm_t, 1);
03788     ALLOC(obs1, obs_t, 1);
03789
03790     /* Set perturbation size... */
03791     if (iqa[j] == IDXP)
03792       h = GSL_MAX(fabs(0.01 * gsl_vector_get(x0, (size_t) j)), 1e-7);
03793     else if (iqa[j] == IDXT)
03794       h = 1;
03795     else if (iqa[j] >= IDXQ(0) && iqa[j] < IDXQ(ctl->ng))
03796       h = GSL_MAX(fabs(0.01 * gsl_vector_get(x0, (size_t) j)), 1e-15);
03797     else if (iqa[j] >= IDXK(0) && iqa[j] < IDXK(ctl->nw))
03798       h = 1e-4;
03799     else
03800       ERRMSG("Cannot set perturbation size!");
03801
03802     /* Disturb state vector element... */
03803     gsl_vector_memcpy(x1, x0);
03804     gsl_vector_set(x1, (size_t) j, gsl_vector_get(x1, (size_t) j) + h);
03805     copy_atm(ctl, atm1, atm, 0);
03806     copy_obs(ctl, obs1, obs, 0);
03807     x2atm(ctl, x1, atm1);
03808
03809     /* Compute radiance for disturbed atmospheric data... */
03810     formod(ctl, atm1, obs1);
03811
03812     /* Compose measurement vector for disturbed radiance data... */
03813     obs2y(ctl, obs1, yy1, NULL, NULL);
03814
03815     /* Compute derivatives... */
03816     for (i = 0; i < m; i++)
03817       gsl_matrix_set(k, i, (size_t) j,
03818                      (gsl_vector_get(yy1, i) - gsl_vector_get(yy0, i)) / h);
03819
03820     /* Free... */
03821     gsl_vector_free(x1);
03822     gsl_vector_free(yy1);
03823     free(atm1);
03824     free(obs1);
03825   }
03826
03827   /* Free... */
03828   gsl_vector_free(x0);
03829   gsl_vector_free(yy0);
03830   free(iqa);
03831 }
```

Here is the call graph for this function:



5.15.2.28 int locate_irr (double * *xx*, int *n*, double *x*)

Find array index for irregular grid.

Definition at line 3835 of file jurassic.c.

```
03838             {
03839
03840   int i, ilo, ihi;
03841
03842   ilo = 0;
03843   ihi = n - 1;
03844   i = (ihi + ilo) >> 1;
03845
03846   if (xx[i] < xx[i + 1])
03847     while (ihi > ilo + 1) {
03848       i = (ihi + ilo) >> 1;
03849       if (xx[i] > x)
03850         ihi = i;
03851       else
03852         ilo = i;
03853   } else
03854     while (ihi > ilo + 1) {
03855       i = (ihi + ilo) >> 1;
03856       if (xx[i] <= x)
03857         ihi = i;
03858       else
03859         ilo = i;
03860     }
03861
03862   return ilo;
03863 }
```

5.15.2.29 int locate_reg (double * *xx*, int *n*, double *x*)

Find array index for regular grid.

Definition at line 3867 of file jurassic.c.

```
03870             {
03871
03872   int i;
03873
03874   /* Calculate index... */
03875   i = (int) ((x - xx[0]) / (xx[1] - xx[0]));
03876
03877   /* Check range... */
03878   if (i < 0)
03879     i = 0;
03880   else if (i >= n - 2)
03881     i = n - 2;
03882
03883   return i;
03884 }
```

5.15.2.30 int locate_tbl (float * *xx*, int *n*, double *x*)

Find array index in float array.

Definition at line 3888 of file jurassic.c.

```
03891             {
03892
03893   int i, ilo, ihi;
03894
03895   ilo = 0;
03896   ihi = n - 1;
03897   i = (ihi + ilo) >> 1;
03898
03899   while (ihi > ilo + 1) {
03900     i = (ihi + ilo) >> 1;
03901     if (xx[i] > x)
03902       ihi = i;
03903     else
03904       ilo = i;
03905   }
03906
03907   return ilo;
03908 }
```

5.15.2.31 size_t obs2y (ctl_t * *ctl*, obs_t * *obs*, gsl_vector * *y*, int * *ida*, int * *ira*)

Compose measurement vector.

Definition at line 3912 of file jurassic.c.

```
03917             {
03918
03919   int id, ir;
03920
03921   size_t m = 0;
03922
03923   /* Determine measurement vector... */
03924   for (ir = 0; ir < obs->nr; ir++)
03925     for (id = 0; id < ctl->nd; id++)
03926       if (gsl_finite(obs->rad[id][ir])) {
03927         if (y != NULL)
03928           gsl_vector_set(y, m, obs->rad[id][ir]);
03929         if (ida != NULL)
03930           ida[m] = id;
03931         if (ira != NULL)
03932           ira[m] = ir;
03933         m++;
03934       }
03935
03936   return m;
03937 }
```

5.15.2.32 double planck (double *t*, double *nu*)

Compute Planck function.

Definition at line 3941 of file jurassic.c.

```
03943             {
03944
03945   return C1 * POW3(nu) / gsl_expm1(C2 * nu / t);
03946 }
```

5.15.2.33 void raytrace (ctl_t * *ctl*, atm_t * *atm*, obs_t * *obs*, los_t * *los*, int *ir*)

Do ray-tracing to determine LOS.

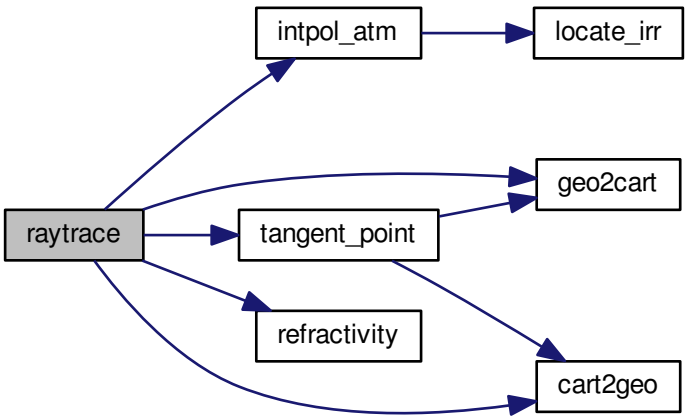
Definition at line 3950 of file jurassic.c.

```
03955           {
03956
03957   double cosa, d, dmax, dmin = 0, ds, ex0[3], ex1[3], frac, h = 0.02, k[NW],
03958     lat, lon, n, naux, ng[3], norm, p, q[NG], t, x[3], xh[3],
03959     xobs[3], xvp[3], z = 1e99, zmax, zmin, zrefrac = 60;
03960
03961   int i, ig, ip, iw, stop = 0;
03962
03963   /* Initialize... */
03964   los->np = 0;
03965   los->tsurf = -999;
03966   obs->tpz[ir] = obs->vpz[ir];
03967   obs->tplon[ir] = obs->vplon[ir];
03968   obs->tplat[ir] = obs->vplat[ir];
03969
03970   /* Get altitude range of atmospheric data... */
03971   gsl_stats_minmax(&zmin, &zmax, atm->z, 1, (size_t) atm->np);
03972
03973   /* Check observer altitude... */
03974   if (obs->obsz[ir] < zmin)
03975     ERRMSG("Observer below surface!");
03976
03977   /* Check view point altitude... */
03978   if (obs->vpz[ir] > zmax)
03979     return;
03980
03981   /* Determine Cartesian coordinates for observer and view point... */
03982   geo2cart(obs->obsz[ir], obs->obslon[ir], obs->obslat[ir], xobs);
03983   geo2cart(obs->vpz[ir], obs->vplon[ir], obs->vplat[ir], xvp);
03984
03985   /* Determine initial tangent vector... */
03986   for (i = 0; i < 3; i++)
03987     ex0[i] = xvp[i] - xobs[i];
03988   norm = NORM(ex0);
03989   for (i = 0; i < 3; i++)
03990     ex0[i] /= norm;
03991
03992   /* Observer within atmosphere... */
03993   for (i = 0; i < 3; i++)
03994     x[i] = xobs[i];
03995
03996   /* Observer above atmosphere (search entry point)... */
03997   if (obs->obsz[ir] > zmax) {
03998     dmax = norm;
03999     while (fabs(dmin - dmax) > 0.001) {
04000       d = (dmax + dmin) / 2;
04001       for (i = 0; i < 3; i++)
04002         x[i] = xobs[i] + d * ex0[i];
04003       cart2geo(x, &z, &lon, &lat);
04004       if (z <= zmax && z > zmax - 0.001)
04005         break;
04006       if (z < zmax - 0.0005)
04007         dmax = d;
04008       else
04009         dmin = d;
04010     }
04011   }
04012
04013   /* Ray-tracing... */
```

```
04014   while (1) {
04015
04016     /* Set step length... */
04017     ds = ctl->rayds;
04018     if (ctl->raydz > 0) {
04019       norm = NORM(x);
04020       for (i = 0; i < 3; i++)
04021         xh[i] = x[i] / norm;
04022       cosa = fabs(DOTP(ex0, xh));
04023       if (cosa != 0)
04024         ds = GSL_MIN(ctl->rayds, ctl->raydz / cosa);
04025     }
04026
04027     /* Determine geolocation... */
04028     cart2geo(x, &z, &lon, &lat);
04029
04030     /* Check if LOS hits the ground or has left atmosphere... */
04031     if (z < zmin || z > zmax) {
04032       stop = (z < zmin ? 2 : 1);
04033       frac =
04034         ((z <
04035           zmin ? zmin : zmax) - los->z[los->np - 1]) / (z - los->z[los->np -
04036                                                                    1]);
04037       geo2cart(los->z[los->np - 1], los->lon[los->np - 1],
04038                los->lat[los->np - 1], xh);
04039       for (i = 0; i < 3; i++)
04040         x[i] = xh[i] + frac * (x[i] - xh[i]);
04041       cart2geo(x, &z, &lon, &lat);
04042       los->ds[los->np - 1] = ds * frac;
04043       ds = 0;
04044     }
04045
04046     /* Interpolate atmospheric data... */
04047     intpol_atm(ctl, atm, z, &p, &t, q, k);
04048
04049     /* Save data... */
04050     los->lon[los->np] = lon;
04051     los->lat[los->np] = lat;
04052     los->z[los->np] = z;
04053     los->p[los->np] = p;
04054     los->t[los->np] = t;
04055     for (ig = 0; ig < ctl->ng; ig++)
04056       los->q[ig][los->np] = q[ig];
04057     for (iw = 0; iw < ctl->nw; iw++)
04058       los->k[iw][los->np] = k[iw];
04059     los->ds[los->np] = ds;
04060
04061     /* Increment and check number of LOS points... */
04062     if ((++los->np) > NLOS)
04063       ERRMSG("Too many LOS points!");
04064
04065     /* Check stop flag... */
04066     if (stop) {
04067       los->tsurf = (stop == 2 ? t : -999);
04068       break;
04069     }
04070
04071     /* Determine refractivity... */
04072     if (ctl->refrac && z <= zrefrac)
04073       n = 1 + refractivity(p, t);
04074     else
04075       n = 1;
04076
04077     /* Construct new tangent vector (first term)... */
04078     for (i = 0; i < 3; i++)
04079       ex1[i] = ex0[i] * n;
04080
04081     /* Compute gradient of refractivity... */
04082     if (ctl->refrac && z <= zrefrac) {
04083       for (i = 0; i < 3; i++)
04084         xh[i] = x[i] + 0.5 * ds * ex0[i];
04085       cart2geo(xh, &z, &lon, &lat);
04086       intpol_atm(ctl, atm, z, &p, &t, q, k);
04087       n = refractivity(p, t);
04088       for (i = 0; i < 3; i++) {
04089         xh[i] += h;
04090         cart2geo(xh, &z, &lon, &lat);
04091         intpol_atm(ctl, atm, z, &p, &t, q, k);
04092         naux = refractivity(p, t);
04093         ng[i] = (naux - n) / h;
04094         xh[i] -= h;
04095       }
04096     } else
04097       for (i = 0; i < 3; i++)
04098         ng[i] = 0;
04099
04100     /* Construct new tangent vector (second term)... */
```

```
04101     for (i = 0; i < 3; i++)
04102       ex1[i] += ds * ng[i];
04103
04104     /* Normalize new tangent vector... */
04105     norm = NORM(ex1);
04106     for (i = 0; i < 3; i++)
04107       ex1[i] /= norm;
04108
04109     /* Determine next point of LOS... */
04110     for (i = 0; i < 3; i++)
04111       x[i] += 0.5 * ds * (ex0[i] + ex1[i]);
04112
04113     /* Copy tangent vector... */
04114     for (i = 0; i < 3; i++)
04115       ex0[i] = ex1[i];
04116   }
04117
04118   /* Get tangent point (to be done before changing segment lengths!)... */
04119   tangent_point(los, &obs->tpz[ir], &obs->tplon[ir], &obs->
      tplat[ir]);
04120
04121   /* Change segment lengths according to trapezoid rule... */
04122   for (ip = los->np - 1; ip >= 1; ip--)
04123     los->ds[ip] = 0.5 * (los->ds[ip - 1] + los->ds[ip]);
04124   los->ds[0] *= 0.5;
04125
04126   /* Compute column density... */
04127   for (ip = 0; ip < los->np; ip++)
04128     for (ig = 0; ig < ctl->ng; ig++)
04129       los->u[ig][ip] = 10 * los->q[ig][ip] * los->p[ip]
04130         / (KB * los->t[ip]) * los->ds[ip];
04131 }
```

Here is the call graph for this function:



5.15.2.34 void read_atm (const char * *dirname*, const char * *filename*, ctl_t * *ctl*, atm_t * *atm*)

Read atmospheric data.

Definition at line 4135 of file jurassic.c.

```
04139               {
04140
04141   FILE *in;
04142
04143   char file[LEN], line[LEN], *tok;
```

```
04144
04145   int ig, iw;
04146
04147   /* Init... */
04148   atm->np = 0;
04149
04150   /* Set filename... */
04151   if (dirname != NULL)
04152     sprintf(file, "%s/%s", dirname, filename);
04153   else
04154     sprintf(file, "%s", filename);
04155
04156   /* Write info... */
04157   printf("Read atmospheric data: %s\n", file);
04158
04159   /* Open file... */
04160   if (!(in = fopen(file, "r")))
04161     ERRMSG("Cannot open file!");
04162
04163   /* Read line... */
04164   while (fgets(line, LEN, in)) {
04165
04166     /* Read data... */
04167     TOK(line, tok, "%lg", atm->time[atm->np]);
04168     TOK(NULL, tok, "%lg", atm->z[atm->np]);
04169     TOK(NULL, tok, "%lg", atm->lon[atm->np]);
04170     TOK(NULL, tok, "%lg", atm->lat[atm->np]);
04171     TOK(NULL, tok, "%lg", atm->p[atm->np]);
04172     TOK(NULL, tok, "%lg", atm->t[atm->np]);
04173     for (ig = 0; ig < ctl->ng; ig++)
04174       TOK(NULL, tok, "%lg", atm->q[ig][atm->np]);
04175     for (iw = 0; iw < ctl->nw; iw++)
04176       TOK(NULL, tok, "%lg", atm->k[iw][atm->np]);
04177
04178     /* Increment data point counter... */
04179     if ((++atm->np) > NP)
04180       ERRMSG("Too many data points!");
04181   }
04182
04183   /* Close file... */
04184   fclose(in);
04185
04186   /* Check number of points... */
04187   if (atm->np < 1)
04188     ERRMSG("Could not read any data!");
04189 }
```

5.15.2.35 void read_ctl (int *argc*, char * *argv[]*, ctl_t * *ctl*)

Read forward model control parameters.

Definition at line 4193 of file jurassic.c.

```
04196               {
04197
04198   int id, ig, iw;
04199
04200   /* Write info... */
04201   printf("\nJuelich Rapid Spectral Simulation Code (JURASSIC)\n"
04202          "(executable: %s | compiled: %s, %s)\n\n",
04203          argv[0], __DATE__, __TIME__);
04204
04205   /* Emitters... */
04206   ctl->ng = (int) scan_ctl(argc, argv, "NG", -1, "0", NULL);
04207   if (ctl->ng < 0 || ctl->ng > NG)
04208     ERRMSG("Set 0 <= NG <= MAX!");
04209   for (ig = 0; ig < ctl->ng; ig++)
04210     scan_ctl(argc, argv, "EMITTER", ig, "", ctl->emitter[ig]);
04211
04212   /* Radiance channels... */
04213   ctl->nd = (int) scan_ctl(argc, argv, "ND", -1, "0", NULL);
04214   if (ctl->nd < 0 || ctl->nd > ND)
04215     ERRMSG("Set 0 <= ND <= MAX!");
04216   for (id = 0; id < ctl->nd; id++)
04217     ctl->nu[id] = scan_ctl(argc, argv, "NU", id, "", NULL);
04218
04219   /* Spectral windows... */
04220   ctl->nw = (int) scan_ctl(argc, argv, "NW", -1, "1", NULL);
04221   if (ctl->nw < 0 || ctl->nw > NW)
04222     ERRMSG("Set 0 <= NW <= MAX!");
```

```
04223   for (id = 0; id < ctl->nd; id++)
04224     ctl->window[id] = (int) scan_ctl(argc, argv, "WINDOW", id, "0", NULL);
04225
04226   /* Emissivity look-up tables... */
04227   scan_ctl(argc, argv, "TBLBASE", -1, "-", ctl->tblbase);
04228
04229   /* Hydrostatic equilibrium... */
04230   ctl->hydz = scan_ctl(argc, argv, "HYDZ", -1, "-999", NULL);
04231
04232   /* Continua... */
04233   ctl->ctm_co2 = (int) scan_ctl(argc, argv, "CTM_CO2", -1, "1", NULL);
04234   ctl->ctm_h2o = (int) scan_ctl(argc, argv, "CTM_H2O", -1, "1", NULL);
04235   ctl->ctm_n2 = (int) scan_ctl(argc, argv, "CTM_N2", -1, "1", NULL);
04236   ctl->ctm_o2 = (int) scan_ctl(argc, argv, "CTM_O2", -1, "1", NULL);
04237
04238   /* Ray-tracing... */
04239   ctl->refrac = (int) scan_ctl(argc, argv, "REFRAC", -1, "1", NULL);
04240   ctl->rayds = scan_ctl(argc, argv, "RAYDS", -1, "10", NULL);
04241   ctl->raydz = scan_ctl(argc, argv, "RAYDZ", -1, "0.5", NULL);
04242
04243   /* Field of view... */
04244   scan_ctl(argc, argv, "FOV", -1, "-", ctl->fov);
04245
04246   /* Retrieval interface... */
04247   ctl->retp_zmin = scan_ctl(argc, argv, "RETP_ZMIN", -1, "-999", NULL);
04248   ctl->retp_zmax = scan_ctl(argc, argv, "RETP_ZMAX", -1, "-999", NULL);
04249   ctl->rett_zmin = scan_ctl(argc, argv, "RETT_ZMIN", -1, "-999", NULL);
04250   ctl->rett_zmax = scan_ctl(argc, argv, "RETT_ZMAX", -1, "-999", NULL);
04251   for (ig = 0; ig < ctl->ng; ig++) {
04252     ctl->retq_zmin[ig] = scan_ctl(argc, argv, "RETQ_ZMIN", ig, "-999", NULL);
04253     ctl->retq_zmax[ig] = scan_ctl(argc, argv, "RETQ_ZMAX", ig, "-999", NULL);
04254   }
04255   for (iw = 0; iw < ctl->nw; iw++) {
04256     ctl->retk_zmin[iw] = scan_ctl(argc, argv, "RETK_ZMIN", iw, "-999", NULL);
04257     ctl->retk_zmax[iw] = scan_ctl(argc, argv, "RETK_ZMAX", iw, "-999", NULL);
04258   }
04259
04260   /* Output flags... */
04261   ctl->write_bbt = (int) scan_ctl(argc, argv, "WRITE_BBT", -1, "0", NULL);
04262   ctl->write_matrix =
04263     (int) scan_ctl(argc, argv, "WRITE_MATRIX", -1, "0", NULL);
04264 }
```

Here is the call graph for this function:

5.15.2.36 void read_matrix (const char * *dirname*, const char * *filename*, gsl_matrix * *matrix*)

Read matrix.

Definition at line 4268 of file jurassic.c.

```
04271                         {
04272
04273   FILE *in;
04274
04275   char dum[LEN], file[LEN], line[LEN];
04276
04277   double value;
04278
04279   int i, j;
04280
04281   /* Set filename... */
```

```
04282   if (dirname != NULL)
04283     sprintf(file, "%s/%s", dirname, filename);
04284   else
04285     sprintf(file, "%s", filename);
04286
04287   /* Write info... */
04288   printf("Read matrix: %s\n", file);
04289
04290   /* Open file... */
04291   if (!(in = fopen(file, "r")))
04292     ERRMSG("Cannot open file!");
04293
04294   /* Read data... */
04295   gsl_matrix_set_zero(matrix);
04296   while (fgets(line, LEN, in))
04297     if (sscanf(line, "%d %s %s %s %s %s %d %s %s %s %s %s %lg",
04298                &i, dum, dum, dum, dum, dum,
04299                &j, dum, dum, dum, dum, dum, &value) == 13)
04300       gsl_matrix_set(matrix, (size_t) i, (size_t) j, value);
04301
04302   /* Close file... */
04303   fclose(in);
04304 }
```

5.15.2.37 void read_obs (const char * *dirname*, const char * *filename*, ctl_t * *ctl*, obs_t * *obs*)

Read observation data.

Definition at line 4308 of file jurassic.c.

```
04312                {
04313
04314   FILE *in;
04315
04316   char file[LEN], line[LEN], *tok;
04317
04318   int id;
04319
04320   /* Init... */
04321   obs->nr = 0;
04322
04323   /* Set filename... */
04324   if (dirname != NULL)
04325     sprintf(file, "%s/%s", dirname, filename);
04326   else
04327     sprintf(file, "%s", filename);
04328
04329   /* Write info... */
04330   printf("Read observation data: %s\n", file);
04331
04332   /* Open file... */
04333   if (!(in = fopen(file, "r")))
04334     ERRMSG("Cannot open file!");
04335
04336   /* Read line... */
04337   while (fgets(line, LEN, in)) {
04338
04339     /* Read data... */
04340     TOK(line, tok, "%lg", obs->time[obs->nr]);
04341     TOK(NULL, tok, "%lg", obs->obsz[obs->nr]);
04342     TOK(NULL, tok, "%lg", obs->obslon[obs->nr]);
04343     TOK(NULL, tok, "%lg", obs->obslat[obs->nr]);
04344     TOK(NULL, tok, "%lg", obs->vpz[obs->nr]);
04345     TOK(NULL, tok, "%lg", obs->vplon[obs->nr]);
04346     TOK(NULL, tok, "%lg", obs->vplat[obs->nr]);
04347     TOK(NULL, tok, "%lg", obs->tpz[obs->nr]);
04348     TOK(NULL, tok, "%lg", obs->tplon[obs->nr]);
04349     TOK(NULL, tok, "%lg", obs->tplat[obs->nr]);
04350     for (id = 0; id < ctl->nd; id++)
04351       TOK(NULL, tok, "%lg", obs->rad[id][obs->nr]);
04352     for (id = 0; id < ctl->nd; id++)
04353       TOK(NULL, tok, "%lg", obs->tau[id][obs->nr]);
04354
04355     /* Increment counter... */
04356     if ((++obs->nr) > NR)
04357       ERRMSG("Too many rays!");
04358   }
04359
04360   /* Close file... */
04361   fclose(in);
```

```
04362
04363   /* Check number of points... */
04364   if (obs->nr < 1)
04365     ERRMSG("Could not read any data!");
04366 }
```

5.15.2.38 void read_shape (const char * *filename*, double * *x*, double * *y*, int * *n*)

Read shape function.

Definition at line 4370 of file jurassic.c.

```
04374           {
04375
04376   FILE *in;
04377
04378   char line[LEN];
04379
04380   /* Write info... */
04381   printf("Read shape function: %s\n", filename);
04382
04383   /* Open file... */
04384   if (!(in = fopen(filename, "r")))
04385     ERRMSG("Cannot open file!");
04386
04387   /* Read data... */
04388   *n = 0;
04389   while (fgets(line, LEN, in))
04390     if (sscanf(line, "%lg %lg", &x[*n], &y[*n]) == 2)
04391       if ((++(*n)) > NSHAPE)
04392         ERRMSG("Too many data points!");
04393
04394   /* Check number of points... */
04395   if (*n < 1)
04396     ERRMSG("Could not read any data!");
04397
04398   /* Close file... */
04399   fclose(in);
04400 }
```

5.15.2.39 double refractivity (double *p*, double *t*)

Compute refractivity (return value is n - 1).

Definition at line 4404 of file jurassic.c.

```
04406             {
04407
04408   /* Refractivity of air at 4 to 15 micron... */
04409   return 7.753e-05 * p / t;
04410 }
```

5.15.2.40 double scan_ctl (int *argc*, char * *argv[]*, const char * *varname*, int *arridx*, const char * *defvalue*, char * *value*)

Search control parameter file for variable entry.

Definition at line 4414 of file jurassic.c.

```
04420               {
04421
04422   FILE *in = NULL;
04423
04424   char dummy[LEN], fullname1[LEN], fullname2[LEN], line[LEN],
04425     msg[2 * LEN], rvarname[LEN], rval[LEN];
04426
04427   int contain = 0, i;
04428
04429   /* Open file... */
04430   if (argv[1][0] != '-')
04431     if (!(in = fopen(argv[1], "r")))
04432       ERRMSG("Cannot open file!");
04433
04434   /* Set full variable name... */
04435   if (arridx >= 0) {
04436     sprintf(fullname1, "%s[%d]", varname, arridx);
04437     sprintf(fullname2, "%s[*]", varname);
04438   } else {
04439     sprintf(fullname1, "%s", varname);
04440     sprintf(fullname2, "%s", varname);
04441   }
04442
04443   /* Read data... */
04444   if (in != NULL)
04445     while (fgets(line, LEN, in))
04446       if (sscanf(line, "%s %s %s", rvarname, dummy, rval) == 3)
04447         if (strcasecmp(rvarname, fullname1) == 0 ||
04448             strcasecmp(rvarname, fullname2) == 0) {
04449           contain = 1;
04450           break;
04451         }
04452   for (i = 1; i < argc - 1; i++)
04453     if (strcasecmp(argv[i], fullname1) == 0 ||
04454         strcasecmp(argv[i], fullname2) == 0) {
04455       sprintf(rval, "%s", argv[i + 1]);
04456       contain = 1;
04457       break;
04458     }
04459
04460   /* Close file... */
04461   if (in != NULL)
04462     fclose(in);
04463
04464   /* Check for missing variables... */
04465   if (!contain) {
04466     if (strlen(defvalue) > 0)
04467       sprintf(rval, "%s", defvalue);
04468     else {
04469       sprintf(msg, "Missing variable %s!\n", fullname1);
04470       ERRMSG(msg);
04471     }
04472   }
04473
04474   /* Write info... */
04475   printf("%s = %s\n", fullname1, rval);
04476
04477   /* Return values... */
04478   if (value != NULL)
04479     sprintf(value, "%s", rval);
04480   return atof(rval);
04481 }
```

5.15.2.41 void tangent_point (los_t * *los*, double * *tpz*, double * *tplon*, double * *tplat*)

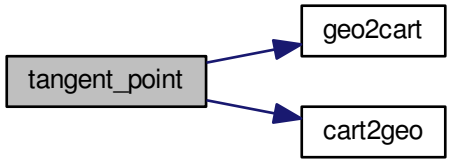
Find tangent point of a given LOS.

Definition at line 4485 of file jurassic.c.

```
04489               {
04490
04491   double a, b, c, dummy, v[3], v0[3], v2[3], x, x1, x2, yy0, yy1, yy2;
04492
04493   size_t i, ip;
04494
04495   /* Find minimum altitude... */
04496   ip = gsl_stats_min_index(los->z, 1, (size_t) los->np);
04497
04498   /* Nadir or zenith... */
04499   if (ip <= 0 || ip >= (size_t) los->np - 1) {
```

```
04500     *tpz = los->z[los->np - 1];
04501     *tplon = los->lon[los->np - 1];
04502     *tplat = los->lat[los->np - 1];
04503   }
04504
04505   /* Limb... */
04506   else {
04507
04508     /* Determine interpolating polynomial y=a*x^2+b*x+c... */
04509     yy0 = los->z[ip - 1];
04510     yy1 = los->z[ip];
04511     yy2 = los->z[ip + 1];
04512     x1 = sqrt(POW2(los->ds[ip]) - POW2(yy1 - yy0));
04513     x2 = x1 + sqrt(POW2(los->ds[ip + 1]) - POW2(yy2 - yy1));
04514     a = 1 / (x1 - x2) * (-(yy0 - yy1) / x1 + (yy0 - yy2) / x2);
04515     b = -(yy0 - yy1) / x1 - a * x1;
04516     c = yy0;
04517
04518     /* Get tangent point location... */
04519     x = -b / (2 * a);
04520     *tpz = a * x * x + b * x + c;
04521     geo2cart(los->z[ip - 1], los->lon[ip - 1], los->lat[ip - 1], v0);
04522     geo2cart(los->z[ip + 1], los->lon[ip + 1], los->lat[ip + 1], v2);
04523     for (i = 0; i < 3; i++)
04524       v[i] = LIN(0.0, v0[i], x2, v2[i], x);
04525     cart2geo(v, &dummy, tplon, tplat);
04526   }
04527 }
```

Here is the call graph for this function:



5.15.2.42 void time2jsec (int *year*, int *mon*, int *day*, int *hour*, int *min*, int *sec*, double *remain*, double * *jsec*)

Convert date to seconds.

Definition at line 4531 of file jurassic.c.

```
04539                 {
04540
04541   struct tm t0, t1;
04542
04543   t0.tm_year = 100;
04544   t0.tm_mon = 0;
04545   t0.tm_mday = 1;
04546   t0.tm_hour = 0;
04547   t0.tm_min = 0;
04548   t0.tm_sec = 0;
04549
04550   t1.tm_year = year - 1900;
04551   t1.tm_mon = mon - 1;
04552   t1.tm_mday = day;
04553   t1.tm_hour = hour;
04554   t1.tm_min = min;
04555   t1.tm_sec = sec;
04556
04557   *jsec = (double) timegm(&t1) - (double) timegm(&t0) + remain;
04558 }
```

5.15.2.43 void timer (const char * *name*, const char * *file*, const char * *func*, int *line*, int *mode*)

Measure wall-clock time.

Definition at line 4562 of file jurassic.c.

```
04567            {
04568
04569   static double w0[10];
04570
04571   static int l0[10], nt;
04572
04573   /* Start new timer... */
04574   if (mode == 1) {
04575     w0[nt] = omp_get_wtime();
04576     l0[nt] = line;
04577     if ((++nt) >= 10)
04578       ERRMSG("Too many timers!");
04579   }
04580
04581   /* Write elapsed time... */
04582   else {
04583
04584     /* Check timer index... */
04585     if (nt - 1 < 0)
04586       ERRMSG("Coding error!");
04587
04588     /* Write elapsed time... */
04589     printf("Timer '%s' (%s, %s, l%d-%d): %.3f sec\n",
04590            name, file, func, l0[nt - 1], line, omp_get_wtime() - w0[nt - 1]);
04591   }
04592
04593   /* Stop timer... */
04594   if (mode == 3)
04595     nt--;
04596 }
```

5.15.2.44 void write_atm (const char * *dirname*, const char * *filename*, ctl_t * *ctl*, atm_t * *atm*)

Write atmospheric data.

Definition at line 4600 of file jurassic.c.

```
04604               {
04605
04606   FILE *out;
04607
04608   char file[LEN];
04609
04610   int ig, ip, iw, n = 6;
04611
04612   /* Set filename... */
04613   if (dirname != NULL)
04614     sprintf(file, "%s/%s", dirname, filename);
04615   else
04616     sprintf(file, "%s", filename);
04617
04618   /* Write info... */
04619   printf("Write atmospheric data: %s\n", file);
04620
04621   /* Create file... */
04622   if (!(out = fopen(file, "w")))
04623     ERRMSG("Cannot create file!");
04624
04625   /* Write header... */
04626   fprintf(out,
04627           "# $1 = time (seconds since 2000-01-01T00:00Z)\n"
04628           "# $2 = altitude [km]\n"
04629           "# $3 = longitude [deg]\n"
04630           "# $4 = latitude [deg]\n"
04631           "# $5 = pressure [hPa]\n" "# $6 = temperature [K]\n");
04632   for (ig = 0; ig < ctl->ng; ig++)
04633     fprintf(out, "# $%d = %s volume mixing ratio\n", ++n, ctl->emitter[ig]);
04634   for (iw = 0; iw < ctl->nw; iw++)
04635     fprintf(out, "# $%d = window %d: extinction [1/km]\n", ++n, iw);
04636
```

```
04637   /* Write data... */
04638   for (ip = 0; ip < atm->np; ip++) {
04639     if (ip == 0 || atm->lat[ip] != atm->lat[ip - 1]
04640         || atm->lon[ip] != atm->lon[ip - 1])
04641       fprintf(out, "\n");
04642     fprintf(out, "%.2f %g %g %g %g %g", atm->time[ip], atm->z[ip],
04643             atm->lon[ip], atm->lat[ip], atm->p[ip], atm->t[ip]);
04644     for (ig = 0; ig < ctl->ng; ig++)
04645       fprintf(out, " %g", atm->q[ig][ip]);
04646     for (iw = 0; iw < ctl->nw; iw++)
04647       fprintf(out, " %g", atm->k[iw][ip]);
04648     fprintf(out, "\n");
04649   }
04650
04651   /* Close file... */
04652   fclose(out);
04653 }
```

5.15.2.45 void write_matrix (const char * *dirname*, const char * *filename*, ctl_t * *ctl*, gsl_matrix * *matrix*, atm_t * *atm*, obs_t * *obs*, const char * *rowspace*, const char * *colspace*, const char * *sort*)

Write matrix.

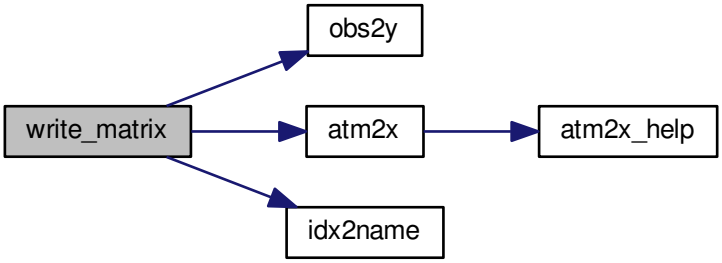
Definition at line 4657 of file jurassic.c.

```
04666                   {
04667
04668   FILE *out;
04669
04670   char file[LEN], quantity[LEN];
04671
04672   int *cida, *ciqa, *cipa, *cira, *rida, *riqa, *ripa, *rira;
04673
04674   size_t i, j, nc, nr;
04675
04676   /* Check output flag... */
04677   if (!ctl->write_matrix)
04678     return;
04679
04680   /* Allocate... */
04681   ALLOC(cida, int, M);
04682   ALLOC(ciqa, int,
04683         N);
04684   ALLOC(cipa, int,
04685         N);
04686   ALLOC(cira, int,
04687         M);
04688   ALLOC(rida, int,
04689         M);
04690   ALLOC(riqa, int,
04691         N);
04692   ALLOC(ripa, int,
04693         N);
04694   ALLOC(rira, int,
04695         M);
04696
04697   /* Set filename... */
04698   if (dirname != NULL)
04699     sprintf(file, "%s/%s", dirname, filename);
04700   else
04701     sprintf(file, "%s", filename);
04702
04703   /* Write info... */
04704   printf("Write matrix: %s\n", file);
04705
04706   /* Create file... */
04707   if (!(out = fopen(file, "w")))
04708     ERRMSG("Cannot create file!");
04709
04710   /* Write header (row space)... */
04711   if (rowspace[0] == 'y') {
04712
04713     fprintf(out,
04714             "# $1 = Row: index (measurement space)\n"
04715             "# $2 = Row: channel wavenumber [cm^-1]\n"
04716             "# $3 = Row: time (seconds since 2000-01-01T00:00Z)\n"
04717             "# $4 = Row: view point altitude [km]\n"
04718             "# $5 = Row: view point longitude [deg]\n"
04719             "# $6 = Row: view point latitude [deg]\n");
04720
```

```
04721     /* Get number of rows... */
04722     nr = obs2y(ctl, obs, NULL, rida, rira);
04723
04724   } else {
04725
04726     fprintf(out,
04727             "# $1 = Row: index (state space)\n"
04728             "# $2 = Row: name of quantity\n"
04729             "# $3 = Row: time (seconds since 2000-01-01T00:00Z)\n"
04730             "# $4 = Row: altitude [km]\n"
04731             "# $5 = Row: longitude [deg]\n" "# $6 = Row: latitude [deg]\n");
04732
04733     /* Get number of rows... */
04734     nr = atm2x(ctl, atm, NULL, riqa, ripa);
04735   }
04736
04737   /* Write header (column space)... */
04738   if (colspace[0] == 'y') {
04739
04740     fprintf(out,
04741             "# $7 = Col: index (measurement space)\n"
04742             "# $8 = Col: channel wavenumber [cm^-1]\n"
04743             "# $9 = Col: time (seconds since 2000-01-01T00:00Z)\n"
04744             "# $10 = Col: view point altitude [km]\n"
04745             "# $11 = Col: view point longitude [deg]\n"
04746             "# $12 = Col: view point latitude [deg]\n");
04747
04748     /* Get number of columns... */
04749     nc = obs2y(ctl, obs, NULL, cida, cira);
04750
04751   } else {
04752
04753     fprintf(out,
04754             "# $7 = Col: index (state space)\n"
04755             "# $8 = Col: name of quantity\n"
04756             "# $9 = Col: time (seconds since 2000-01-01T00:00Z)\n"
04757             "# $10 = Col: altitude [km]\n"
04758             "# $11 = Col: longitude [deg]\n" "# $12 = Col: latitude [deg]\n");
04759
04760     /* Get number of columns... */
04761     nc = atm2x(ctl, atm, NULL, ciqa, cipa);
04762   }
04763
04764   /* Write header entry... */
04765   fprintf(out, "# $13 = Matrix element\n\n");
04766
04767   /* Write matrix data... */
04768   i = j = 0;
04769   while (i < nr && j < nc) {
04770
04771     /* Write info about the row... */
04772     if (rowspace[0] == 'y')
04773       fprintf(out, "%d %g %.2f %g %g %g",
04774               (int) i, ctl->nu[rida[i]],
04775               obs->time[rira[i]], obs->vpz[rira[i]],
04776               obs->vplon[rira[i]], obs->vplat[rira[i]]);
04777     else {
04778       idx2name(ctl, riqa[i], quantity);
04779       fprintf(out, "%d %s %.2f %g %g %g", (int) i, quantity,
04780               atm->time[ripa[i]], atm->z[ripa[i]],
04781               atm->lon[ripa[i]], atm->lat[ripa[i]]);
04782     }
04783
04784     /* Write info about the column... */
04785     if (colspace[0] == 'y')
04786       fprintf(out, " %d %g %.2f %g %g %g",
04787               (int) j, ctl->nu[cida[j]],
04788               obs->time[cira[j]], obs->vpz[cira[j]],
04789               obs->vplon[cira[j]], obs->vplat[cira[j]]);
04790     else {
04791       idx2name(ctl, ciqa[j], quantity);
04792       fprintf(out, " %d %s %.2f %g %g %g", (int) j, quantity,
04793               atm->time[cipa[j]], atm->z[cipa[j]],
04794               atm->lon[cipa[j]], atm->lat[cipa[j]]);
04795     }
04796
04797     /* Write matrix entry... */
04798     fprintf(out, " %g\n", gsl_matrix_get(matrix, i, j));
04799
04800     /* Set matrix indices... */
04801     if (sort[0] == 'r') {
04802       j++;
04803       if (j >= nc) {
04804         j = 0;
04805         i++;
04806         fprintf(out, "\n");
04807       }
```

```
04808     } else {
04809       i++;
04810       if (i >= nr) {
04811         i = 0;
04812         j++;
04813         fprintf(out, "\n");
04814       }
04815     }
04816   }
04817
04818   /* Close file... */
04819   fclose(out);
04820
04821   /* Free... */
04822   free(cida);
04823   free(ciqa);
04824   free(cipa);
04825   free(cira);
04826   free(rida);
04827   free(riqa);
04828   free(ripa);
04829   free(rira);
04830 }
```

Here is the call graph for this function:



5.15.2.46 void write_obs (const char * *dirname*, const char * *filename*, ctl_t * *ctl*, obs_t * *obs*)

Write observation data.

Definition at line 4834 of file jurassic.c.

```
04838                {
04839
04840   FILE *out;
04841
04842   char file[LEN];
04843
04844   int id, ir, n = 10;
04845
04846   /* Set filename... */
04847   if (dirname != NULL)
04848     sprintf(file, "%s/%s", dirname, filename);
04849   else
04850     sprintf(file, "%s", filename);
04851
04852   /* Write info... */
04853   printf("Write observation data: %s\n", file);
04854
04855   /* Create file... */
04856   if (!(out = fopen(file, "w")))
04857     ERRMSG("Cannot create file!");
04858
```

```
04859   /* Write header... */
04860   fprintf(out,
04861           "# $1 = time (seconds since 2000-01-01T00:00Z)\n"
04862           "# $2 = observer altitude [km]\n"
04863           "# $3 = observer longitude [deg]\n"
04864           "# $4 = observer latitude [deg]\n"
04865           "# $5 = view point altitude [km]\n"
04866           "# $6 = view point longitude [deg]\n"
04867           "# $7 = view point latitude [deg]\n"
04868           "# $8 = tangent point altitude [km]\n"
04869           "# $9 = tangent point longitude [deg]\n"
04870           "# $10 = tangent point latitude [deg]\n");
04871   for (id = 0; id < ctl->nd; id++)
04872     fprintf(out, "# $%d = channel %g: radiance [W/(m^2 sr cm^-1)]\n",
04873             ++n, ctl->nu[id]);
04874   for (id = 0; id < ctl->nd; id++)
04875     fprintf(out, "# $%d = channel %g: transmittance\n", ++n, ctl->nu[id]);
04876
04877   /* Write data... */
04878   for (ir = 0; ir < obs->nr; ir++) {
04879     if (ir == 0 || obs->time[ir] != obs->time[ir - 1])
04880       fprintf(out, "\n");
04881     fprintf(out, "%.2f %g %g %g %g %g %g %g %g %g", obs->time[ir],
04882             obs->obsz[ir], obs->obslon[ir], obs->obslat[ir],
04883             obs->vpz[ir], obs->vplon[ir], obs->vplat[ir],
04884             obs->tpz[ir], obs->tplon[ir], obs->tplat[ir]);
04885     for (id = 0; id < ctl->nd; id++)
04886       fprintf(out, " %g", obs->rad[id][ir]);
04887     for (id = 0; id < ctl->nd; id++)
04888       fprintf(out, " %g", obs->tau[id][ir]);
04889     fprintf(out, "\n");
04890   }
04891
04892   /* Close file... */
04893   fclose(out);
04894 }
```

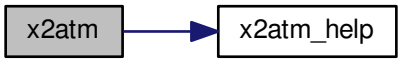
5.15.2.47 void x2atm (ctl_t * *ctl*, gsl_vector * *x*, atm_t * *atm*)

Decompose parameter vector or state vector.

Definition at line 4898 of file jurassic.c.

```
04901                 {
04902
04903   int ig, iw;
04904
04905   size_t n = 0;
04906
04907   /* Set pressure... */
04908   x2atm_help(atm, ctl->retp_zmin, ctl->retp_zmax, atm->
      p, x, &n);
04909
04910   /* Set temperature... */
04911   x2atm_help(atm, ctl->rett_zmin, ctl->rett_zmax, atm->
      t, x, &n);
04912
04913   /* Set volume mixing ratio... */
04914   for (ig = 0; ig < ctl->ng; ig++)
04915     x2atm_help(atm, ctl->retq_zmin[ig], ctl->retq_zmax[ig],
04916                atm->q[ig], x, &n);
04917
04918   /* Set extinction... */
04919   for (iw = 0; iw < ctl->nw; iw++)
04920     x2atm_help(atm, ctl->retk_zmin[iw], ctl->retk_zmax[iw],
04921                atm->k[iw], x, &n);
04922 }
```

Here is the call graph for this function:



5.15.2.48 void x2atm_help (atm_t * *atm*, double *zmin*, double *zmax*, double * *value*, gsl_vector * *x*, size_t * *n*)

Extract elements from state vector.

Definition at line 4926 of file jurassic.c.

```
04932               {
04933
04934   int ip;
04935
04936   /* Extract state vector elements... */
04937   for (ip = 0; ip < atm->np; ip++)
04938     if (atm->z[ip] >= zmin && atm->z[ip] <= zmax) {
04939       value[ip] = gsl_vector_get(x, *n);
04940       (*n)++;
04941     }
04942 }
```

5.15.2.49 void y2obs (ctl_t * *ctl*, gsl_vector * *y*, obs_t * *obs*)

Decompose measurement vector.

Definition at line 4946 of file jurassic.c.

```
04949                {
04950
04951   int id, ir;
04952
04953   size_t m = 0;
04954
04955   /* Decompose measurement vector... */
04956   for (ir = 0; ir < obs->nr; ir++)
04957     for (id = 0; id < ctl->nd; id++)
04958       if (gsl_finite(obs->rad[id][ir])) {
04959         obs->rad[id][ir] = gsl_vector_get(y, m);
04960         m++;
04961       }
04962 }
```

5.16 jurassic.h

```
00001 /*
00002   This file is part of JURASSIC.
00003
00004   JURASSIC is free software: you can redistribute it and/or modify
00005   it under the terms of the GNU General Public License as published by
00006   the Free Software Foundation, either version 3 of the License, or
00007   (at your option) any later version.
00008
00009   JURASSIC is distributed in the hope that it will be useful,
00010   but WITHOUT ANY WARRANTY; without even the implied warranty of
00011   MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.  See the
00012   GNU General Public License for more details.
00013
00014   You should have received a copy of the GNU General Public License
00015   along with JURASSIC. If not, see <http://www.gnu.org/licenses/>.
00016
00017   Copyright (C) 2003-2015 Forschungszentrum Juelich GmbH
00018 */
00019
00034 #include <gsl/gsl_math.h>
00035 #include <gsl/gsl_blas.h>
00036 #include <gsl/gsl_linalg.h>
00037 #include <gsl/gsl_statistics.h>
00038 #include <math.h>
00039 #include <omp.h>
00040 #include <stdio.h>
00041 #include <stdlib.h>
00042 #include <string.h>
00043 #include <time.h>
00044
00045 /* ------------------------------------------------------------
```

```
00046    Macros...
00047    ------------------------------------------------------------ */
00048
00050 #define ALLOC(ptr, type, n)                             \
00051   if((ptr=malloc((size_t)(n)*sizeof(type)))==NULL)      \
00052     ERRMSG("Out of memory!");
00053
00055 #define DIST(a, b) sqrt(DIST2(a, b))
00056
00058 #define DIST2(a, b)                                                     \
00059   ((a[0]-b[0])*(a[0]-b[0])+(a[1]-b[1])*(a[1]-b[1])+(a[2]-b[2])*(a[2]-b[2]))
00060
00062 #define DOTP(a, b) (a[0]*b[0]+a[1]*b[1]+a[2]*b[2])
00063
00065 #define ERRMSG(msg) {                                                   \
00066     printf("\nError (%s, %s, l%d): %s\n\n",                             \
00067            __FILE__, __func__, __LINE__, msg);                          \
00068     exit(EXIT_FAILURE);                                                 \
00069   }
00070
00072 #define EXP(x0, y0, x1, y1, x)                                  \
00073   (((y0)>0 && (y1)>0)                                           \
00074    ? ((y0)*exp(log((y1)/(y0))/((x1)-(x0))*((x)-(x0))))          \
00075    : LIN(x0, y0, x1, y1, x))
00076
00078 #define LIN(x0, y0, x1, y1, x)                  \
00079   ((y0)+((y1)-(y0))/((x1)-(x0))*((x)-(x0)))
00080
00082 #define NORM(a) sqrt(DOTP(a, a))
00083
00085 #define POW2(x) ((x)*(x))
00086
00088 #define POW3(x) ((x)*(x)*(x))
00089
00091 #define PRINT(format, var)                                              \
00092   printf("Print (%s, %s, l%d): %s= "format"\n",                         \
00093          __FILE__, __func__, __LINE__, #var, var);
00094
00096 #define TIMER(name, mode)                               \
00097   {timer(name, __FILE__, __func__, __LINE__, mode);}
00098
00100 #define TOK(line, tok, format, var) {                   \
00101     if(((tok)=strtok((line), " \t"))) {                 \
00102       if(sscanf(tok, format, &(var))!=1) continue;      \
00103     } else ERRMSG("Error while reading!");              \
00104   }
00105
00106 /* ------------------------------------------------------------
00107    Constants...
00108    ------------------------------------------------------------ */
00109
00111 #define TMIN 100.
00112
00114 #define TMAX 400.
00115
00117 #define C1 1.19104259e-8
00118
00120 #define C2 1.43877506
00121
00123 #define G0 9.80665
00124
00126 #define KB 1.3806504e-23
00127
00129 #define NA 6.02214199e23
00130
00132 #define P0 1013.25
00133
00135 #define T0 273.15
00136
00138 #define RE 6367.421
00139
00141 #define RI 8.3144598
00142
00144 #define ME 5.976e24
00145
00146 /* ------------------------------------------------------------
00147    Dimensions...
00148    ------------------------------------------------------------ */
00149
00151 #define ND 50
00152
00154 #define NG 20
00155
00157 #define NP 1000
00158
00160 #define NR 1000
00161
```

```
00163 #define NW 5
00164
00166 #define LEN 5000
00167
00169 #define M (NR*ND)
00170
00172 #define N (NQ*NP)
00173
00175 #define NQ (2+NG+NW)
00176
00178 #define NLOS 1000
00179
00181 #define NSHAPE 10000
00182
00184 #define NFOV 5
00185
00187 #define TBLNP 41
00188
00190 #define TBLNT 30
00191
00193 #define TBLNU 320
00194
00196 #define TBLNS 1200
00197
00198 /* -------------------------------------------------------------
00199    Quantity indices...
00200    ------------------------------------------------------------- */
00201
00203 #define IDXP 0
00204
00206 #define IDXT 1
00207
00209 #define IDXQ(ig) (2+ig)
00210
00212 #define IDXK(iw) (2+ctl->ng+iw)
00213
00214 /* -------------------------------------------------------------
00215    Structs...
00216    ------------------------------------------------------------- */
00217
00219 typedef struct {
00220
00222   int np;
00223
00225   double time[NP];
00226
00228   double z[NP];
00229
00231   double lon[NP];
00232
00234   double lat[NP];
00235
00237   double p[NP];
00238
00240   double t[NP];
00241
00243   double q[NG][NP];
00244
00246   double k[NW][NP];
00247
00248 } atm_t;
00249
00251 typedef struct {
00252
00254   int ng;
00255
00257   char emitter[NG][LEN];
00258
00260   int nd;
00261
00263   int nw;
00264
00266   double nu[ND];
00267
00269   int window[ND];
00270
00272   char tblbase[LEN];
00273
00275   double hydz;
00276
00278   int ctm_co2;
00279
00281   int ctm_h2o;
00282
00284   int ctm_n2;
00285
00287   int ctm_o2;
```

```
00288
00290   int refrac;
00291
00293   double rayds;
00294
00296   double raydz;
00297
00299   char fov[LEN];
00300
00302   double retp_zmin;
00303
00305   double retp_zmax;
00306
00308   double rett_zmin;
00309
00311   double rett_zmax;
00312
00314   double retq_zmin[NG];
00315
00317   double retq_zmax[NG];
00318
00320   double retk_zmin[NW];
00321
00323   double retk_zmax[NW];
00324
00326   int write_bbt;
00327
00329   int write_matrix;
00330
00331 } ctl_t;
00332
00334 typedef struct {
00335
00337   int np;
00338
00340   double z[NLOS];
00341
00343   double lon[NLOS];
00344
00346   double lat[NLOS];
00347
00349   double p[NLOS];
00350
00352   double t[NLOS];
00353
00355   double q[NG][NLOS];
00356
00358   double k[NW][NLOS];
00359
00361   double tsurf;
00362
00364   double ds[NLOS];
00365
00367   double u[NG][NLOS];
00368
00369 } los_t;
00370
00372 typedef struct {
00373
00375   int nr;
00376
00378   double time[NR];
00379
00381   double obsz[NR];
00382
00384   double obslon[NR];
00385
00387   double obslat[NR];
00388
00390   double vpz[NR];
00391
00393   double vplon[NR];
00394
00396   double vplat[NR];
00397
00399   double tpz[NR];
00400
00402   double tplon[NR];
00403
00405   double tplat[NR];
00406
00408   double tau[ND][NR];
00409
00411   double rad[ND][NR];
00412
00413 } obs_t;
00414
```

```
00416 typedef struct {
00417
00419   int np[NG][ND];
00420
00422   int nt[NG][ND][TBLNP];
00423
00425   int nu[NG][ND][TBLNP][TBLNT];
00426
00428   double p[NG][ND][TBLNP];
00429
00431   double t[NG][ND][TBLNP][TBLNT];
00432
00434   float u[NG][ND][TBLNP][TBLNT][TBLNU];
00435
00437   float eps[NG][ND][TBLNP][TBLNT][TBLNU];
00438
00440   double st[TBLNS];
00441
00443   double sr[ND][TBLNS];
00444
00445 } tbl_t;
00446
00447 /* ------------------------------------------------------------
00448    Functions...
00449    ------------------------------------------------------------ */
00450
00452 size_t atm2x(
00453   ctl_t * ctl,
00454   atm_t * atm,
00455   gsl_vector * x,
00456   int *iqa,
00457   int *ipa);
00458
00460 void atm2x_help(
00461   atm_t * atm,
00462   double zmin,
00463   double zmax,
00464   double *value,
00465   int val_iqa,
00466   gsl_vector * x,
00467   int *iqa,
00468   int *ipa,
00469   size_t * n);
00470
00472 double brightness(
00473   double rad,
00474   double nu);
00475
00477 void cart2geo(
00478   double *x,
00479   double *z,
00480   double *lon,
00481   double *lat);
00482
00484 void climatology(
00485   ctl_t * ctl,
00486   atm_t * atm_mean);
00487
00489 double ctmco2(
00490   double nu,
00491   double p,
00492   double t,
00493   double u);
00494
00496 double ctmh2o(
00497   double nu,
00498   double p,
00499   double t,
00500   double q,
00501   double u);
00502
00504 double ctmn2(
00505   double nu,
00506   double p,
00507   double t);
00508
00510 double ctmo2(
00511   double nu,
00512   double p,
00513   double t);
00514
00516 void copy_atm(
00517   ctl_t * ctl,
00518   atm_t * atm_dest,
00519   atm_t * atm_src,
00520   int init);
00521
```

```
00523 void copy_obs(
00524   ctl_t * ctl,
00525   obs_t * obs_dest,
00526   obs_t * obs_src,
00527   int init);
00528
00530 int find_emitter(
00531   ctl_t * ctl,
00532   const char *emitter);
00533
00535 void formod(
00536   ctl_t * ctl,
00537   atm_t * atm,
00538   obs_t * obs);
00539
00541 void formod_continua(
00542   ctl_t * ctl,
00543   los_t * los,
00544   int ip,
00545   double *beta);
00546
00548 void formod_fov(
00549   ctl_t * ctl,
00550   obs_t * obs);
00551
00553 void formod_pencil(
00554   ctl_t * ctl,
00555   atm_t * atm,
00556   obs_t * obs,
00557   int ir);
00558
00560 void formod_srcfunc(
00561   ctl_t * ctl,
00562   tbl_t * tbl,
00563   double t,
00564   double *src);
00565
00567 void geo2cart(
00568   double z,
00569   double lon,
00570   double lat,
00571   double *x);
00572
00574 void hydrostatic(
00575   ctl_t * ctl,
00576   atm_t * atm);
00577
00579 void idx2name(
00580   ctl_t * ctl,
00581   int idx,
00582   char *quantity);
00583
00585 void init_tbl(
00586   ctl_t * ctl,
00587   tbl_t * tbl);
00588
00590 void intpol_atm(
00591   ctl_t * ctl,
00592   atm_t * atm,
00593   double z,
00594   double *p,
00595   double *t,
00596   double *q,
00597   double *k);
00598
00600 void intpol_tbl(
00601   ctl_t * ctl,
00602   tbl_t * tbl,
00603   los_t * los,
00604   int ip,
00605   double tau_path[NG][ND],
00606   double tau_seg[ND]);
00607
00609 double intpol_tbl_eps(
00610   tbl_t * tbl,
00611   int ig,
00612   int id,
00613   int ip,
00614   int it,
00615   double u);
00616
00618 double intpol_tbl_u(
00619   tbl_t * tbl,
00620   int ig,
00621   int id,
00622   int ip,
00623   int it,
```

```
00624   double eps);
00625
00627 void jsec2time(
00628   double jsec,
00629   int *year,
00630   int *mon,
00631   int *day,
00632   int *hour,
00633   int *min,
00634   int *sec,
00635   double *remain);
00636
00638 void kernel(
00639   ctl_t * ctl,
00640   atm_t * atm,
00641   obs_t * obs,
00642   gsl_matrix * k);
00643
00645 int locate_irr(
00646   double *xx,
00647   int n,
00648   double x);
00649
00651 int locate_reg(
00652   double *xx,
00653   int n,
00654   double x);
00655
00657 int locate_tbl(
00658   float *xx,
00659   int n,
00660   double x);
00661
00663 size_t obs2y(
00664   ctl_t * ctl,
00665   obs_t * obs,
00666   gsl_vector * y,
00667   int *ida,
00668   int *ira);
00669
00671 double planck(
00672   double t,
00673   double nu);
00674
00676 void raytrace(
00677   ctl_t * ctl,
00678   atm_t * atm,
00679   obs_t * obs,
00680   los_t * los,
00681   int ir);
00682
00684 void read_atm(
00685   const char *dirname,
00686   const char *filename,
00687   ctl_t * ctl,
00688   atm_t * atm);
00689
00691 void read_ctl(
00692   int argc,
00693   char *argv[],
00694   ctl_t * ctl);
00695
00697 void read_matrix(
00698   const char *dirname,
00699   const char *filename,
00700   gsl_matrix * matrix);
00701
00703 void read_obs(
00704   const char *dirname,
00705   const char *filename,
00706   ctl_t * ctl,
00707   obs_t * obs);
00708
00710 void read_shape(
00711   const char *filename,
00712   double *x,
00713   double *y,
00714   int *n);
00715
00717 double refractivity(
00718   double p,
00719   double t);
00720
00722 double scan_ctl(
00723   int argc,
00724   char *argv[],
00725   const char *varname,
```

```
00726   int arridx,
00727   const char *defvalue,
00728   char *value);
00729
00731 void tangent_point(
00732   los_t * los,
00733   double *tpz,
00734   double *tplon,
00735   double *tplat);
00736
00738 void time2jsec(
00739   int year,
00740   int mon,
00741   int day,
00742   int hour,
00743   int min,
00744   int sec,
00745   double remain,
00746   double *jsec);
00747
00749 void timer(
00750   const char *name,
00751   const char *file,
00752   const char *func,
00753   int line,
00754   int mode);
00755
00757 void write_atm(
00758   const char *dirname,
00759   const char *filename,
00760   ctl_t * ctl,
00761   atm_t * atm);
00762
00764 void write_matrix(
00765   const char *dirname,
00766   const char *filename,
00767   ctl_t * ctl,
00768   gsl_matrix * matrix,
00769   atm_t * atm,
00770   obs_t * obs,
00771   const char *rowspace,
00772   const char *colspace,
00773   const char *sort);
00774
00776 void write_obs(
00777   const char *dirname,
00778   const char *filename,
00779   ctl_t * ctl,
00780   obs_t * obs);
00781
00783 void x2atm(
00784   ctl_t * ctl,
00785   gsl_vector * x,
00786   atm_t * atm);
00787
00789 void x2atm_help(
00790   atm_t * atm,
00791   double zmin,
00792   double zmax,
00793   double *value,
00794   gsl_vector * x,
00795   size_t * n);
00796
00798 void y2obs(
00799   ctl_t * ctl,
00800   gsl_vector * y,
00801   obs_t * obs);
```

5.17 kernel.c File Reference

Calculate kernel functions.

Functions

- int main (int argc, char ∗argv[ ])

5.17.1 Detailed Description

Calculate kernel functions.

Definition in file kernel.c.

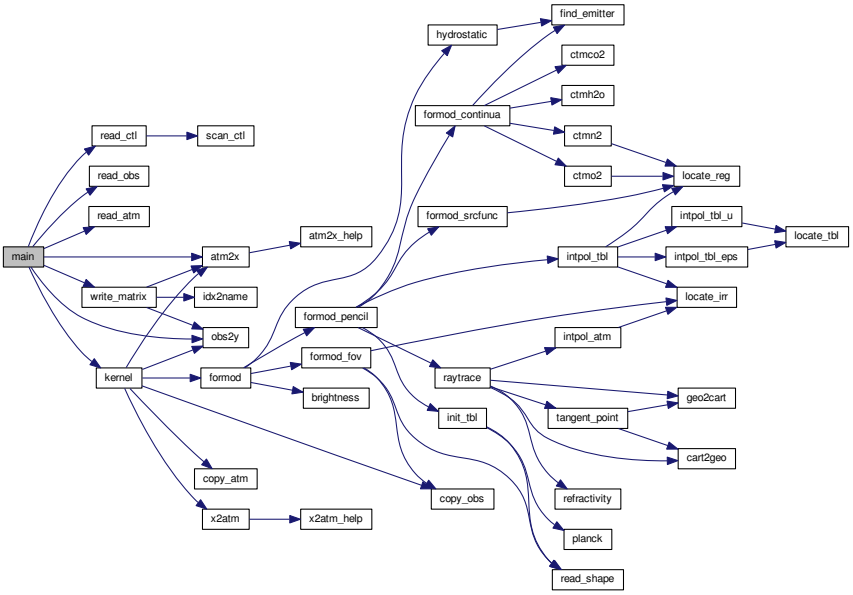
5.17.2 Function Documentation

5.17.2.1 int main (int *argc*, char * *argv[]*)

Definition at line 27 of file kernel.c.

```
00029                 {
00030
00031   static atm_t atm;
00032   static ctl_t ctl;
00033   static obs_t obs;
00034
00035   gsl_matrix *k;
00036
00037   size_t m, n;
00038
00039   /* Check arguments... */
00040   if (argc < 5)
00041     ERRMSG("Give parameters: <ctl> <obs> <atm> <kernel>");
00042
00043   /* Read control parameters... */
00044   read_ctl(argc, argv, &ctl);
00045
00046   /* Set flags... */
00047   ctl.write_matrix = 1;
00048
00049   /* Read observation geometry... */
00050   read_obs(NULL, argv[2], &ctl, &obs);
00051
00052   /* Read atmospheric data... */
00053   read_atm(NULL, argv[3], &ctl, &atm);
00054
00055   /* Get sizes... */
00056   n = atm2x(&ctl, &atm, NULL, NULL, NULL);
00057   m = obs2y(&ctl, &obs, NULL, NULL, NULL);
00058
00059   /* Check sizes... */
00060   if (n <= 0)
00061     ERRMSG("No state vector elements!");
00062   if (m <= 0)
00063     ERRMSG("No measurement vector elements!");
00064
00065   /* Allocate... */
00066   k = gsl_matrix_alloc(m, n);
00067
00068   /* Compute kernel matrix... */
00069   kernel(&ctl, &atm, &obs, k);
00070
00071   /* Write matrix to file... */
00072   write_matrix(NULL, argv[4], &ctl, k, &atm, &obs, "y", "x", "r");
00073
00074   /* Free... */
00075   gsl_matrix_free(k);
00076
00077   return EXIT_SUCCESS;
00078 }
```

Here is the call graph for this function:



5.18 kernel.c

```
00001 /*
00002   This file is part of JURASSIC.
00003
00004   JURASSIC is free software: you can redistribute it and/or modify
00005   it under the terms of the GNU General Public License as published by
00006   the Free Software Foundation, either version 3 of the License, or
00007   (at your option) any later version.
00008
00009   JURASSIC is distributed in the hope that it will be useful,
00010   but WITHOUT ANY WARRANTY; without even the implied warranty of
00011   MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.  See the
00012   GNU General Public License for more details.
00013
00014   You should have received a copy of the GNU General Public License
00015   along with JURASSIC. If not, see <http://www.gnu.org/licenses/>.
00016
00017   Copright (C) 2003-2015 Forschungszentrum Juelich GmbH
00018 */
00019
00025 #include "jurassic.h"
00026
00027 int main(
00028   int argc,
00029   char *argv[]) {
00030
00031   static atm_t atm;
00032   static ctl_t ctl;
00033   static obs_t obs;
00034
00035   gsl_matrix *k;
00036
00037   size_t m, n;
00038
00039   /* Check arguments... */
00040   if (argc < 5)
00041     ERRMSG("Give parameters: <ctl> <obs> <atm> <kernel>");
00042
00043   /* Read control parameters... */
00044   read_ctl(argc, argv, &ctl);
00045
00046   /* Set flags... */
00047   ctl.write_matrix = 1;
00048
00049   /* Read observation geometry... */
```

```
00050   read_obs(NULL, argv[2], &ctl, &obs);
00051
00052   /* Read atmospheric data... */
00053   read_atm(NULL, argv[3], &ctl, &atm);
00054
00055   /* Get sizes... */
00056   n = atm2x(&ctl, &atm, NULL, NULL, NULL);
00057   m = obs2y(&ctl, &obs, NULL, NULL, NULL);
00058
00059   /* Check sizes... */
00060   if (n <= 0)
00061     ERRMSG("No state vector elements!");
00062   if (m <= 0)
00063     ERRMSG("No measurement vector elements!");
00064
00065   /* Allocate... */
00066   k = gsl_matrix_alloc(m, n);
00067
00068   /* Compute kernel matrix... */
00069   kernel(&ctl, &atm, &obs, k);
00070
00071   /* Write matrix to file... */
00072   write_matrix(NULL, argv[4], &ctl, k, &atm, &obs, "y", "x", "r");
00073
00074   /* Free... */
00075   gsl_matrix_free(k);
00076
00077   return EXIT_SUCCESS;
00078 }
```

5.19 limb.c File Reference

Create observation geometry for a limb sounder.

Functions

- int main (int argc, char ∗argv[ ])

5.19.1 Detailed Description

Create observation geometry for a limb sounder.

Definition in file limb.c.

5.19.2 Function Documentation

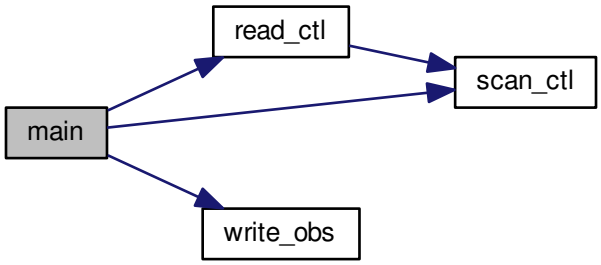
5.19.2.1 int main (int *argc*, char ∗ *argv[ ]*)

Definition at line 27 of file limb.c.

```
00029                {
00030
00031   static ctl_t ctl;
00032   static obs_t obs;
00033
00034   double dz, obsz, z, z0, z1;
00035
00036   /* Check arguments... */
00037   if (argc < 3)
00038     ERRMSG("Give parameters: <ctl> <obs>");
00039
00040   /* Read control parameters... */
00041   read_ctl(argc, argv, &ctl);
00042   obsz = scan_ctl(argc, argv, "OBSZ", -1, "780", NULL);
00043   z0 = scan_ctl(argc, argv, "Z0", -1, "6", NULL);
```

```
00044   z1 = scan_ctl(argc, argv, "Z1", -1, "70", NULL);
00045   dz = scan_ctl(argc, argv, "DZ", -1, "1.5", NULL);
00046
00047   /* Create measurement geometry... */
00048   for (z = z0; z <= z1; z += dz) {
00049     obs.obsz[obs.nr] = obsz;
00050     obs.vpz[obs.nr] = z;
00051     obs.vplat[obs.nr] = 180 / M_PI * acos((RE + z) / (RE + obsz));
00052     if ((++obs.nr) >= NR)
00053       ERRMSG("Too many rays!");
00054   }
00055
00056   /* Write observation data... */
00057   write_obs(NULL, argv[2], &ctl, &obs);
00058
00059   return EXIT_SUCCESS;
00060 }
```

Here is the call graph for this function:



5.20 limb.c

```
00001 /*
00002   This file is part of JURASSIC.
00003
00004   JURASSIC is free software: you can redistribute it and/or modify
00005   it under the terms of the GNU General Public License as published by
00006   the Free Software Foundation, either version 3 of the License, or
00007   (at your option) any later version.
00008
00009   JURASSIC is distributed in the hope that it will be useful,
00010   but WITHOUT ANY WARRANTY; without even the implied warranty of
00011   MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.  See the
00012   GNU General Public License for more details.
00013
00014   You should have received a copy of the GNU General Public License
00015   along with JURASSIC. If not, see <http://www.gnu.org/licenses/>.
00016
00017   Copyright (C) 2003-2015 Forschungszentrum Juelich GmbH
00018 */
00019
00025 #include "jurassic.h"
00026
00027 int main(
00028   int argc,
00029   char *argv[]) {
00030
00031   static ctl_t ctl;
00032   static obs_t obs;
00033
00034   double dz, obsz, z, z0, z1;
00035
00036   /* Check arguments... */
00037   if (argc < 3)
00038     ERRMSG("Give parameters: <ctl> <obs>");
00039
```

```
00040   /* Read control parameters... */
00041   read_ctl(argc, argv, &ctl);
00042   obsz = scan_ctl(argc, argv, "OBSZ", -1, "780", NULL);
00043   z0 = scan_ctl(argc, argv, "Z0", -1, "6", NULL);
00044   z1 = scan_ctl(argc, argv, "Z1", -1, "70", NULL);
00045   dz = scan_ctl(argc, argv, "DZ", -1, "1.5", NULL);
00046
00047   /* Create measurement geometry... */
00048   for (z = z0; z <= z1; z += dz) {
00049     obs.obsz[obs.nr] = obsz;
00050     obs.vpz[obs.nr] = z;
00051     obs.vplat[obs.nr] = 180 / M_PI * acos((RE + z) / (RE + obsz));
00052     if ((++obs.nr) >= NR)
00053       ERRMSG("Too many rays!");
00054   }
00055
00056   /* Write observation data... */
00057   write_obs(NULL, argv[2], &ctl, &obs);
00058
00059   return EXIT_SUCCESS;
00060 }
```

5.21 nadir.c File Reference

Create observation geometry for a nadir sounder.

Functions

- int main (int argc, char ∗argv[ ])

5.21.1 Detailed Description

Create observation geometry for a nadir sounder.

Definition in file nadir.c.

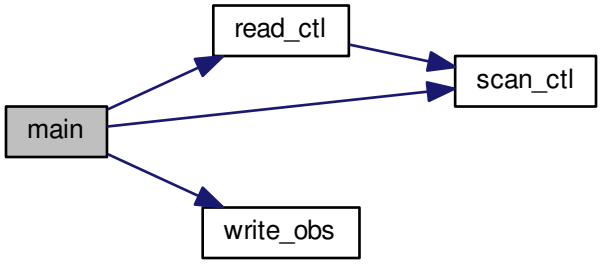
5.21.2 Function Documentation

5.21.2.1 int main (int *argc,* char ∗ *argv[ ]*)

Definition at line 27 of file nadir.c.

```
00029                {
00030
00031   static ctl_t ctl;
00032   static obs_t obs;
00033
00034   double dlat, lat, lat0, lat1, obsz;
00035
00036   /* Check arguments... */
00037   if (argc < 3)
00038     ERRMSG("Give parameters: <ctl> <obs>");
00039
00040   /* Read control parameters... */
00041   read_ctl(argc, argv, &ctl);
00042   obsz = scan_ctl(argc, argv, "OBSZ", -1, "700", NULL);
00043   lat0 = scan_ctl(argc, argv, "LAT0", -1, "-8.01", NULL);
00044   lat1 = scan_ctl(argc, argv, "LAT1", -1, "8.01", NULL);
00045   dlat = scan_ctl(argc, argv, "DLAT", -1, "0.18", NULL);
00046
00047   /* Create measurement geometry... */
00048   for (lat = lat0; lat <= lat1; lat += dlat) {
00049     obs.obsz[obs.nr] = obsz;
00050     obs.vplat[obs.nr] = lat;
00051     if ((++obs.nr) >= NR)
00052       ERRMSG("Too many rays!");
00053   }
00054
00055   /* Write observation data... */
00056   write_obs(NULL, argv[2], &ctl, &obs);
00057
00058   return EXIT_SUCCESS;
00059 }
```

Here is the call graph for this function:



5.22 nadir.c

```
00001 /*
00002   This file is part of JURASSIC.
00003
00004   JURASSIC is free software: you can redistribute it and/or modify
00005   it under the terms of the GNU General Public License as published by
00006   the Free Software Foundation, either version 3 of the License, or
00007   (at your option) any later version.
00008
00009   JURASSIC is distributed in the hope that it will be useful,
00010   but WITHOUT ANY WARRANTY; without even the implied warranty of
00011   MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.  See the
00012   GNU General Public License for more details.
00013
00014   You should have received a copy of the GNU General Public License
00015   along with JURASSIC. If not, see <http://www.gnu.org/licenses/>.
00016
00017   Copyright (C) 2003-2015 Forschungszentrum Juelich GmbH
00018 */
00019
00025 #include "jurassic.h"
00026
00027 int main(
00028   int argc,
00029   char *argv[]) {
00030
00031   static ctl_t ctl;
00032   static obs_t obs;
00033
00034   double dlat, lat, lat0, lat1, obsz;
00035
00036   /* Check arguments... */
00037   if (argc < 3)
00038     ERRMSG("Give parameters: <ctl> <obs>");
00039
00040   /* Read control parameters... */
00041   read_ctl(argc, argv, &ctl);
00042   obsz = scan_ctl(argc, argv, "OBSZ", -1, "700", NULL);
00043   lat0 = scan_ctl(argc, argv, "LAT0", -1, "-8.01", NULL);
00044   lat1 = scan_ctl(argc, argv, "LAT1", -1, "8.01", NULL);
00045   dlat = scan_ctl(argc, argv, "DLAT", -1, "0.18", NULL);
00046
00047   /* Create measurement geometry... */
00048   for (lat = lat0; lat <= lat1; lat += dlat) {
00049     obs.obsz[obs.nr] = obsz;
00050     obs.vplat[obs.nr] = lat;
00051     if ((++obs.nr) >= NR)
00052       ERRMSG("Too many rays!");
00053   }
00054
00055   /* Write observation data... */
00056   write_obs(NULL, argv[2], &ctl, &obs);
00057
00058   return EXIT_SUCCESS;
00059 }
```

5.23 planck.c File Reference

Convert brightness temperature to radiance.

Functions

- int main (int argc, char ∗argv[ ])

5.23.1 Detailed Description

Convert brightness temperature to radiance.

Definition in file planck.c.

5.23.2 Function Documentation

5.23.2.1 int main (int *argc*, char ∗ *argv[ ]*)

Definition at line 27 of file planck.c.

```
00029                {
00030
00031   double nu, t;
00032
00033   /* Check arguments... */
00034   if (argc < 3)
00035     ERRMSG("Give parameters: <t> <nu>");
00036
00037   /* Read arguments... */
00038   t = atof(argv[1]);
00039   nu = atof(argv[2]);
00040
00041   /* Compute Planck function... */
00042   printf("%.10g\n", planck(t, nu));
00043
00044   return EXIT_SUCCESS;
00045 }
```

Here is the call graph for this function:

5.24 planck.c

```
00001 /*
00002   This file is part of JURASSIC.
00003
00004   JURASSIC is free software: you can redistribute it and/or modify
00005   it under the terms of the GNU General Public License as published by
00006   the Free Software Foundation, either version 3 of the License, or
00007   (at your option) any later version.
00008
00009   JURASSIC is distributed in the hope that it will be useful,
00010   but WITHOUT ANY WARRANTY; without even the implied warranty of
00011   MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.  See the
00012   GNU General Public License for more details.
00013
00014   You should have received a copy of the GNU General Public License
00015   along with JURASSIC. If not, see <http://www.gnu.org/licenses/>.
00016
00017   Copyright (C) 2003-2015 Forschungszentrum Juelich GmbH
00018 */
00019
00025 #include "jurassic.h"
00026
00027 int main(
00028   int argc,
00029   char *argv[]) {
00030
00031   double nu, t;
00032
00033   /* Check arguments... */
00034   if (argc < 3)
00035     ERRMSG("Give parameters: <t> <nu>");
00036
00037   /* Read arguments... */
00038   t = atof(argv[1]);
00039   nu = atof(argv[2]);
00040
00041   /* Compute Planck function... */
00042   printf("%.10g\n", planck(t, nu));
00043
00044   return EXIT_SUCCESS;
00045 }
```

5.25 raytrace.c File Reference

Determine atmospheric ray paths.

Functions

- int main (int argc, char *argv[])

5.25.1 Detailed Description

Determine atmospheric ray paths.

Definition in file raytrace.c.

5.25.2 Function Documentation

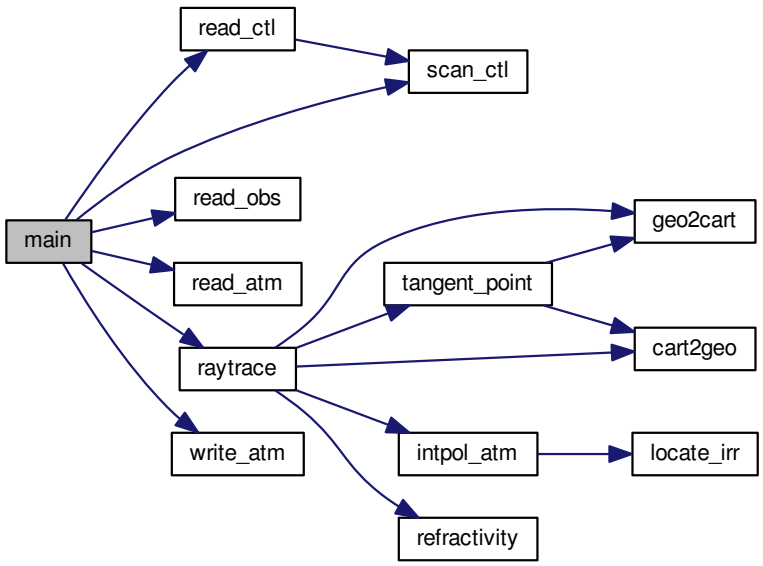
5.25.2.1 int main (int *argc*, char * *argv[]*)

Definition at line 27 of file raytrace.c.

```
00029                {
00030
00031   static atm_t atm, atm2;
00032   static ctl_t ctl;
00033   static los_t los;
00034   static obs_t obs;
00035
00036   FILE *out;
00037
00038   char filename[LEN], losbase[LEN];
00039
00040   double u[NG], s;
00041
00042   int ig, ip, ir, iw;
00043
00044   /* Check arguments... */
00045   if (argc < 4)
00046     ERRMSG("Give parameters: <ctl> <obs> <atm>");
00047
00048   /* Read control parameters... */
00049   read_ctl(argc, argv, &ctl);
00050
00051   /* Get basenames... */
00052   scan_ctl(argc, argv, "LOSBASE", -1, "los", losbase);
00053
00054   /* Read observation geometry... */
00055   read_obs(NULL, argv[2], &ctl, &obs);
00056
00057   /* Read atmospheric data... */
00058   read_atm(NULL, argv[3], &ctl, &atm);
00059
00060   /* Write info... */
00061   printf("Write raytrace data: raytrace.tab\n");
00062
00063   /* Create file... */
00064   if (!(out = fopen("raytrace.tab", "w")))
00065     ERRMSG("Cannot create file!");
00066
00067   /* Write header... */
00068   fprintf(out,
00069           "# $1 = time (seconds since 2000-01-01T00:00Z)\n"
00070           "# $2 = observer altitude [km]\n"
00071           "# $3 = observer longitude [deg]\n"
00072           "# $4 = observer latitude [deg]\n"
00073           "# $5 = view point altitude [km]\n"
00074           "# $6 = view point longitude [deg]\n"
00075           "# $7 = view point latitude [deg]\n"
00076           "# $8 = tangent point altitude [km]\n"
00077           "# $9 = tangent point longitude [deg]\n"
00078           "# $10 = tangent point latitude [deg]\n"
00079           "# $11 = ray path index\n" "# $12 = ray path length [km]\n");
00080   for (ig = 0; ig < ctl.ng; ig++)
00081     fprintf(out, "# $%d = %s column density [molec/cm^2]\n",
00082             13 + ig, ctl.emitter[ig]);
00083   fprintf(out, "\n");
00084
00085   /* Loop over rays... */
00086   for (ir = 0; ir < obs.nr; ir++) {
00087
00088     /* Raytracing... */
00089     raytrace(&ctl, &atm, &obs, &los, ir);
00090
00091     /* Copy data... */
00092     atm2.np = los.np;
00093     for (ip = 0; ip < los.np; ip++) {
00094       atm2.time[ip] = obs.time[ir];
00095       atm2.z[ip] = los.z[ip];
00096       atm2.lon[ip] = los.lon[ip];
00097       atm2.lat[ip] = los.lat[ip];
00098       atm2.p[ip] = los.p[ip];
00099       atm2.t[ip] = los.t[ip];
00100       for (ig = 0; ig < ctl.ng; ig++)
00101         atm2.q[ig][ip] = los.q[ig][ip];
00102       for (iw = 0; iw < ctl.nw; iw++)
00103         atm2.k[iw][ip] = los.k[iw][ip];
00104     }
```

```
00105
00106     /* Save data... */
00107     sprintf(filename, "los.%d", ir);
00108     write_atm(NULL, filename, &ctl, &atm2);
00109
00110     /* Get column densities... */
00111     s = 0;
00112     for (ig = 0; ig < ctl.ng; ig++)
00113       u[ig] = 0;
00114     for (ip = 0; ip < los.np; ip++) {
00115       s += los.ds[ip];
00116       for (ig = 0; ig < ctl.ng; ig++)
00117         u[ig] += los.u[ig][ip];
00118     }
00119
00120     /* Write summary data... */
00121     fprintf(out, "%.2f %g %g %g %g %g %g %g %g %d %g",
00122             obs.time[ir], obs.obsz[ir], obs.obslon[ir], obs.obslat[ir],
00123             obs.vpz[ir], obs.vplon[ir], obs.vplat[ir],
00124             obs.tpz[ir], obs.tplon[ir], obs.tplat[ir], ir, s);
00125     for (ig = 0; ig < ctl.ng; ig++)
00126       fprintf(out, " %g", u[ig]);
00127     fprintf(out, "\n");
00128   }
00129
00130   /* Close file... */
00131   fclose(out);
00132
00133   return EXIT_SUCCESS;
00134 }
```

Here is the call graph for this function:



5.26 raytrace.c

```
00001 /*
00002   This file is part of JURASSIC.
00003
00004   JURASSIC is free software: you can redistribute it and/or modify
00005   it under the terms of the GNU General Public License as published by
00006   the Free Software Foundation, either version 3 of the License, or
00007   (at your option) any later version.
00008
```

```
00009   JURASSIC is distributed in the hope that it will be useful,
00010   but WITHOUT ANY WARRANTY; without even the implied warranty of
00011   MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.  See the
00012   GNU General Public License for more details.
00013
00014   You should have received a copy of the GNU General Public License
00015   along with JURASSIC. If not, see <http://www.gnu.org/licenses/>.
00016
00017   Copyright (C) 2003-2015 Forschungszentrum Juelich GmbH
00018 */
00019
00025 #include "jurassic.h"
00026
00027 int main(
00028   int argc,
00029   char *argv[]) {
00030
00031   static atm_t atm, atm2;
00032   static ctl_t ctl;
00033   static los_t los;
00034   static obs_t obs;
00035
00036   FILE *out;
00037
00038   char filename[LEN], losbase[LEN];
00039
00040   double u[NG], s;
00041
00042   int ig, ip, ir, iw;
00043
00044   /* Check arguments... */
00045   if (argc < 4)
00046     ERRMSG("Give parameters: <ctl> <obs> <atm>");
00047
00048   /* Read control parameters... */
00049   read_ctl(argc, argv, &ctl);
00050
00051   /* Get basenames... */
00052   scan_ctl(argc, argv, "LOSBASE", -1, "los", losbase);
00053
00054   /* Read observation geometry... */
00055   read_obs(NULL, argv[2], &ctl, &obs);
00056
00057   /* Read atmospheric data... */
00058   read_atm(NULL, argv[3], &ctl, &atm);
00059
00060   /* Write info... */
00061   printf("Write raytrace data: raytrace.tab\n");
00062
00063   /* Create file... */
00064   if (!(out = fopen("raytrace.tab", "w")))
00065     ERRMSG("Cannot create file!");
00066
00067   /* Write header... */
00068   fprintf(out,
00069           "# $1 = time (seconds since 2000-01-01T00:00Z)\n"
00070           "# $2 = observer altitude [km]\n"
00071           "# $3 = observer longitude [deg]\n"
00072           "# $4 = observer latitude [deg]\n"
00073           "# $5 = view point altitude [km]\n"
00074           "# $6 = view point longitude [deg]\n"
00075           "# $7 = view point latitude [deg]\n"
00076           "# $8 = tangent point altitude [km]\n"
00077           "# $9 = tangent point longitude [deg]\n"
00078           "# $10 = tangent point latitude [deg]\n"
00079           "# $11 = ray path index\n" "# $12 = ray path length [km]\n");
00080   for (ig = 0; ig < ctl.ng; ig++)
00081     fprintf(out, "# $%d = %s column density [molec/cm^2]\n",
00082             13 + ig, ctl.emitter[ig]);
00083   fprintf(out, "\n");
00084
00085   /* Loop over rays... */
00086   for (ir = 0; ir < obs.nr; ir++) {
00087
00088     /* Raytracing... */
00089     raytrace(&ctl, &atm, &obs, &los, ir);
00090
00091     /* Copy data... */
00092     atm2.np = los.np;
00093     for (ip = 0; ip < los.np; ip++) {
00094       atm2.time[ip] = obs.time[ir];
00095       atm2.z[ip] = los.z[ip];
00096       atm2.lon[ip] = los.lon[ip];
00097       atm2.lat[ip] = los.lat[ip];
00098       atm2.p[ip] = los.p[ip];
00099       atm2.t[ip] = los.t[ip];
00100       for (ig = 0; ig < ctl.ng; ig++)
```

```
00101         atm2.q[ig][ip] = los.q[ig][ip];
00102       for (iw = 0; iw < ctl.nw; iw++)
00103         atm2.k[iw][ip] = los.k[iw][ip];
00104     }
00105
00106     /* Save data... */
00107     sprintf(filename, "los.%d", ir);
00108     write_atm(NULL, filename, &ctl, &atm2);
00109
00110     /* Get column densities... */
00111     s = 0;
00112     for (ig = 0; ig < ctl.ng; ig++)
00113       u[ig] = 0;
00114     for (ip = 0; ip < los.np; ip++) {
00115       s += los.ds[ip];
00116       for (ig = 0; ig < ctl.ng; ig++)
00117         u[ig] += los.u[ig][ip];
00118     }
00119
00120     /* Write summary data... */
00121     fprintf(out, "%.2f %g %g %g %g %g %g %g %g %d %g",
00122             obs.time[ir], obs.obsz[ir], obs.obslon[ir], obs.obslat[ir],
00123             obs.vpz[ir], obs.vplon[ir], obs.vplat[ir],
00124             obs.tpz[ir], obs.tplon[ir], obs.tplat[ir], ir, s);
00125     for (ig = 0; ig < ctl.ng; ig++)
00126       fprintf(out, " %g", u[ig]);
00127     fprintf(out, "\n");
00128   }
00129
00130   /* Close file... */
00131   fclose(out);
00132
00133   return EXIT_SUCCESS;
00134 }
```

5.27 retrieval.c File Reference

JURASSIC retrieval processor.

Data Structures

- struct ret_t

  Retrieval control parameters.

Functions

- void analyze_avk (ret_t *ret, ctl_t *ctl, atm_t *atm, int *iqa, int *ipa, gsl_matrix *avk)

  Compute information content and resolution.
- void analyze_avk_quantity (gsl_matrix *avk, int iq, int *ipa, size_t *n0, size_t *n1, double *cont, double *res)

  Analyze averaging kernels for individual retrieval target.
- double cost_function (gsl_vector *dx, gsl_vector *dy, gsl_matrix *s_a_inv, gsl_vector *sig_eps_inv)

  Compute cost function.
- void matrix_invert (gsl_matrix *a)

  Invert symmetric matrix.
- void matrix_product (gsl_matrix *a, gsl_vector *b, int transpose, gsl_matrix *c)

  Compute matrix product A^TBA or ABA^T for diagonal matrix B.
- void optimal_estimation (ret_t *ret, ctl_t *ctl, obs_t *obs_meas, obs_t *obs_i, atm_t *atm_apr, atm_t *atm_i)

  Carry out optimal estimation retrieval.
- void read_ret (int argc, char *argv[], ctl_t *ctl, ret_t *ret)

  Read retrieval control parameters.
- void set_cov_apr (ret_t *ret, ctl_t *ctl, atm_t *atm, int *iqa, int *ipa, gsl_matrix *s_a)

  Set a priori covariance.

- void set_cov_meas (ret_t *ret, ctl_t *ctl, obs_t *obs, gsl_vector *sig_noise, gsl_vector *sig_formod, gsl_↩ vector *sig_eps_inv)

  Set measurement errors.
- void write_stddev (const char *quantity, ret_t *ret, ctl_t *ctl, atm_t *atm, gsl_matrix *s)

  Write retrieval error to file.
- int main (int argc, char *argv[ ])

5.27.1 Detailed Description

JURASSIC retrieval processor.

Definition in file retrieval.c.

5.27.2 Function Documentation

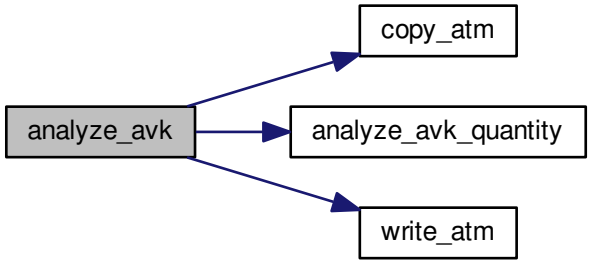
5.27.2.1 void analyze_avk (ret_t * *ret,* ctl_t * *ctl,* atm_t * *atm,* int * *iqa,* int * *ipa,* gsl_matrix * *avk*)

Compute information content and resolution.

Definition at line 236 of file retrieval.c.

```
00242                     {
00243
00244   static atm_t atm_cont, atm_res;
00245
00246   int ig, iq, iw;
00247
00248   size_t i, n, n0[NQ], n1[NQ];
00249
00250   /* Get sizes... */
00251   n = avk->size1;
00252
00253   /* Find sub-matrices for different quantities... */
00254   for (iq = 0; iq < NQ; iq++) {
00255     n0[iq] = N;
00256     for (i = 0; i < n; i++) {
00257       if (iqa[i] == iq && n0[iq] == N)
00258         n0[iq] = i;
00259       if (iqa[i] == iq)
00260         n1[iq] = i - n0[iq] + 1;
00261     }
00262   }
00263
00264   /* Initialize... */
00265   copy_atm(ctl, &atm_cont, atm, 1);
00266   copy_atm(ctl, &atm_res, atm, 1);
00267
00268   /* Analyze quantities... */
00269   analyze_avk_quantity(avk, IDXP, ipa, n0, n1, atm_cont.p, atm_res.
      p);
00270   analyze_avk_quantity(avk, IDXT, ipa, n0, n1, atm_cont.t, atm_res.
      t);
00271   for (ig = 0; ig < ctl->ng; ig++)
00272     analyze_avk_quantity(avk, IDXQ(ig), ipa, n0, n1,
00273                          atm_cont.q[ig], atm_res.q[ig]);
00274   for (iw = 0; iw < ctl->nw; iw++)
00275     analyze_avk_quantity(avk, IDXK(iw), ipa, n0, n1,
00276                          atm_cont.k[iw], atm_res.k[iw]);
00277
00278   /* Write results to disk... */
00279   write_atm(ret->dir, "atm_cont.tab", ctl, &atm_cont);
00280   write_atm(ret->dir, "atm_res.tab", ctl, &atm_res);
00281 }
```

Here is the call graph for this function:



5.27.2.2 void analyze_avk_quantity (gsl_matrix * *avk*, int *iq*, int * *ipa*, size_t * *n0*, size_t * *n1*, double * *cont*, double * *res*)

Analyze averaging kernels for individual retrieval target.

Definition at line 285 of file retrieval.c.

```
00292                {
00293
00294   size_t i, j;
00295
00296   /* Loop over state vector elements... */
00297   if (n0[iq] < N)
00298     for (i = 0; i < n1[iq]; i++) {
00299
00300       /* Get area of averagig kernel... */
00301       for (j = 0; j < n1[iq]; j++)
00302         cont[ipa[n0[iq] + i]] += gsl_matrix_get(avk, n0[iq] + i, n0[iq] + j);
00303
00304       /* Get information density... */
00305       res[ipa[n0[iq] + i]] = 1 / gsl_matrix_get(avk, n0[iq] + i, n0[iq] + i);
00306     }
00307 }
```

5.27.2.3 double cost_function (gsl_vector * *dx*, gsl_vector * *dy*, gsl_matrix * *s_a_inv*, gsl_vector * *sig_eps_inv*)

Compute cost function.

Definition at line 311 of file retrieval.c.

```
00315                             {
00316
00317   gsl_vector *x_aux, *y_aux;
00318
00319   double chisq_a, chisq_m = 0;
00320
00321   size_t i, m, n;
00322
00323   /* Get sizes... */
00324   m = dy->size;
00325   n = dx->size;
00326
00327   /* Allocate... */
00328   x_aux = gsl_vector_alloc(n);
00329   y_aux = gsl_vector_alloc(m);
00330
00331   /* Determine normalized cost function...
```

```
00332       (chi^2 = 1/m * [dy^T * S_eps^{-1} * dy + dx^T * S_a^{-1} * dx]) */
00333   for (i = 0; i < m; i++)
00334     chisq_m += POW2(gsl_vector_get(dy, i) * gsl_vector_get(sig_eps_inv, i));
00335   gsl_blas_dgemv(CblasNoTrans, 1.0, s_a_inv, dx, 0.0, x_aux);
00336   gsl_blas_ddot(dx, x_aux, &chisq_a);
00337
00338   /* Free... */
00339   gsl_vector_free(x_aux);
00340   gsl_vector_free(y_aux);
00341
00342   /* Return cost function value... */
00343   return (chisq_m + chisq_a) / (double) m;
00344 }
```

5.27.2.4 void matrix_invert (gsl_matrix * *a*)

Invert symmetric matrix.

Definition at line 348 of file retrieval.c.

```
00349                   {
00350
00351   size_t diag = 1, i, j, n;
00352
00353   /* Get size... */
00354   n = a->size1;
00355
00356   /* Check if matrix is diagonal... */
00357   for (i = 0; i < n && diag; i++)
00358     for (j = i + 1; j < n; j++)
00359       if (gsl_matrix_get(a, i, j) != 0) {
00360         diag = 0;
00361         break;
00362       }
00363
00364   /* Quick inversion of diagonal matrix... */
00365   if (diag)
00366     for (i = 0; i < n; i++)
00367       gsl_matrix_set(a, i, i, 1 / gsl_matrix_get(a, i, i));
00368
00369   /* Matrix inversion by means of Cholesky decomposition... */
00370   else {
00371     gsl_linalg_cholesky_decomp(a);
00372     gsl_linalg_cholesky_invert(a);
00373   }
00374 }
```

5.27.2.5 void matrix_product (gsl_matrix * *a*, gsl_vector * *b*, int *transpose*, gsl_matrix * *c*)

Compute matrix product A^TBA or ABA^T for diagonal matrix B.

Definition at line 378 of file retrieval.c.

```
00382                   {
00383
00384   gsl_matrix *aux;
00385
00386   size_t i, j, m, n;
00387
00388   /* Set sizes... */
00389   m = a->size1;
00390   n = a->size2;
00391
00392   /* Allocate... */
00393   aux = gsl_matrix_alloc(m, n);
00394
00395   /* Compute A^T B A... */
00396   if (transpose == 1) {
00397
00398     /* Compute B^1/2 A... */
00399     for (i = 0; i < m; i++)
00400       for (j = 0; j < n; j++)
00401         gsl_matrix_set(aux, i, j,
00402                        gsl_vector_get(b, i) * gsl_matrix_get(a, i, j));
```

```
00403
00404     /* Compute A^T B A = (B^1/2 A)^T (B^1/2 A)... */
00405     gsl_blas_dgemm(CblasTrans, CblasNoTrans, 1.0, aux, aux, 0.0, c);
00406   }
00407
00408   /* Compute A B A^T... */
00409   else if (transpose == 2) {
00410
00411     /* Compute A B^1/2... */
00412     for (i = 0; i < m; i++)
00413       for (j = 0; j < n; j++)
00414         gsl_matrix_set(aux, i, j,
00415                        gsl_matrix_get(a, i, j) * gsl_vector_get(b, j));
00416
00417     /* Compute A B A^T = (A B^1/2) (A B^1/2)^T... */
00418     gsl_blas_dgemm(CblasNoTrans, CblasTrans, 1.0, aux, aux, 0.0, c);
00419   }
00420
00421   /* Free... */
00422   gsl_matrix_free(aux);
00423 }
```

5.27.2.6 void optimal_estimation (ret_t * *ret*, ctl_t * *ctl*, obs_t * *obs_meas*, obs_t * *obs_i*, atm_t * *atm_apr*, atm_t * *atm_i*)

Carry out optimal estimation retrieval.

Definition at line 427 of file retrieval.c.

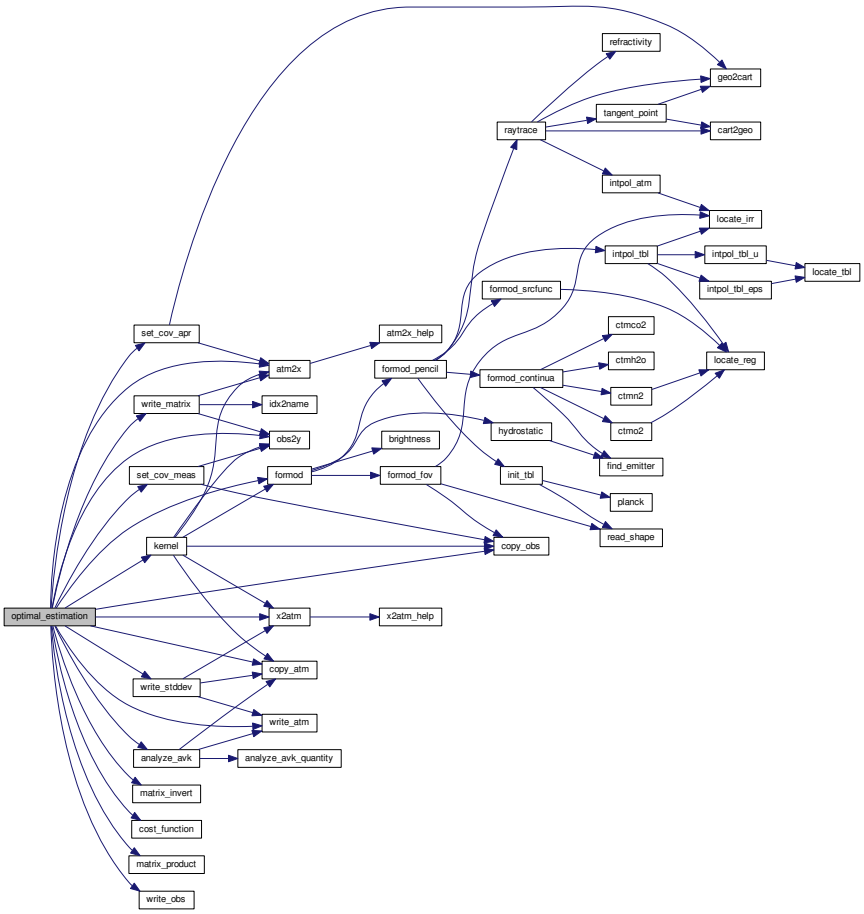
```
00433                 {
00434
00435   static int ipa[N], iqa[N];
00436
00437   gsl_matrix *a, *auxnm, *corr, *cov, *gain, *k_i, *s_a_inv;
00438   gsl_vector *b, *dx, *dy, *sig_eps_inv, *sig_formod, *sig_noise,
00439     *x_a, *x_i, *x_step, *y_aux, *y_i, *y_m;
00440
00441   FILE *out;
00442
00443   char filename[LEN];
00444
00445   double chisq, chisq_old, disq = 0, lmpar = 0.001;
00446
00447   int ig, ip, it = 0, it2, iw;
00448
00449   size_t i, j, m, n;
00450
00451   /* ------------------------------------------------------------
00452      Initialize...
00453      ------------------------------------------------------------ */
00454
00455   /* Get sizes... */
00456   m = obs2y(ctl, obs_meas, NULL, NULL, NULL);
00457   n = atm2x(ctl, atm_apr, NULL, iqa, ipa);
00458   if (m <= 0 || n <= 0)
00459     ERRMSG("Check problem definition!");
00460
00461   /* Write info... */
00462   printf("Problem size: m= %d / n= %d "
00463          "(alloc= %.4g MB / stat= %.4g MB)\n",
00464          (int) m, (int) n,
00465          (double) (3 * m * n + 4 * n * n + 8 * m +
00466                    8 * n) * sizeof(double) / 1024. / 1024.,
00467          (double) (5 * sizeof(atm_t) + 3 * sizeof(obs_t)
00468                    + 2 * N * sizeof(int)) / 1024. / 1024.);
00469
00470   /* Allocate... */
00471   a = gsl_matrix_alloc(n, n);
00472   cov = gsl_matrix_alloc(n, n);
00473   k_i = gsl_matrix_alloc(m, n);
00474   s_a_inv = gsl_matrix_alloc(n, n);
00475
00476   b = gsl_vector_alloc(n);
00477   dx = gsl_vector_alloc(n);
00478   dy = gsl_vector_alloc(m);
00479   sig_eps_inv = gsl_vector_alloc(m);
00480   sig_formod = gsl_vector_alloc(m);
00481   sig_noise = gsl_vector_alloc(m);
00482   x_a = gsl_vector_alloc(n);
00483   x_i = gsl_vector_alloc(n);
```

```
00484   x_step = gsl_vector_alloc(n);
00485   y_aux = gsl_vector_alloc(m);
00486   y_i = gsl_vector_alloc(m);
00487   y_m = gsl_vector_alloc(m);
00488
00489   /* Set initial state... */
00490   copy_atm(ctl, atm_i, atm_apr, 0);
00491   copy_obs(ctl, obs_i, obs_meas, 0);
00492   formod(ctl, atm_i, obs_i);
00493
00494   /* Set state vectors and observation vectors... */
00495   atm2x(ctl, atm_apr, x_a, NULL, NULL);
00496   atm2x(ctl, atm_i, x_i, NULL, NULL);
00497   obs2y(ctl, obs_meas, y_m, NULL, NULL);
00498   obs2y(ctl, obs_i, y_i, NULL, NULL);
00499
00500   /* Set inverse a priori covariance S_a^-1... */
00501   set_cov_apr(ret, ctl, atm_apr, iqa, ipa, s_a_inv);
00502   write_matrix(ret->dir, "matrix_cov_apr.tab", ctl, s_a_inv,
00503                atm_i, obs_i, "x", "x", "r");
00504   matrix_invert(s_a_inv);
00505
00506   /* Get measurement errors... */
00507   set_cov_meas(ret, ctl, obs_meas, sig_noise, sig_formod, sig_eps_inv);
00508
00509   /* Create cost function file... */
00510   sprintf(filename, "%s/costs.tab", ret->dir);
00511   if (!(out = fopen(filename, "w")))
00512     ERRMSG("Cannot create cost function file!");
00513
00514   /* Write header... */
00515   fprintf(out,
00516           "# $1 = iteration number\n"
00517           "# $2 = normalized cost function\n"
00518           "# $3 = number of measurements\n"
00519           "# $4 = number of state vector elements\n\n");
00520
00521   /* Determine dx = x_i - x_a and dy = y - F(x_i) ... */
00522   gsl_vector_memcpy(dx, x_i);
00523   gsl_vector_sub(dx, x_a);
00524   gsl_vector_memcpy(dy, y_m);
00525   gsl_vector_sub(dy, y_i);
00526
00527   /* Compute cost function... */
00528   chisq = cost_function(dx, dy, s_a_inv, sig_eps_inv);
00529
00530   /* Write info... */
00531   printf("it= %d / chi^2/m= %g\n", it, chisq);
00532
00533   /* Write to cost function file... */
00534   fprintf(out, "%d %g %d %d\n", it, chisq, (int) m, (int) n);
00535
00536   /* Compute initial kernel... */
00537   kernel(ctl, atm_i, obs_i, k_i);
00538
00539   /* ------------------------------------------------------------
00540      Levenberg-Marquardt minimization...
00541      ------------------------------------------------------------ */
00542
00543   /* Outer loop... */
00544   for (it = 1; it <= ret->conv_itmax; it++) {
00545
00546     /* Store current cost function value... */
00547     chisq_old = chisq;
00548
00549     /* Compute kernel matrix K_i... */
00550     if (it > 1 && it % ret->kernel_recomp == 0)
00551       kernel(ctl, atm_i, obs_i, k_i);
00552
00553     /* Compute K_i^T * S_eps^{-1} * K_i ... */
00554     if (it == 1 || it % ret->kernel_recomp == 0)
00555       matrix_product(k_i, sig_eps_inv, 1, cov);
00556
00557     /* Determine b = K_i^T * S_eps^{-1} * dy - S_a^{-1} * dx ... */
00558     for (i = 0; i < m; i++)
00559       gsl_vector_set(y_aux, i, gsl_vector_get(dy, i)
00560                      * POW2(gsl_vector_get(sig_eps_inv, i)));
00561     gsl_blas_dgemv(CblasTrans, 1.0, k_i, y_aux, 0.0, b);
00562     gsl_blas_dgemv(CblasNoTrans, -1.0, s_a_inv, dx, 1.0, b);
00563
00564     /* Inner loop... */
00565     for (it2 = 0; it2 < 20; it2++) {
00566
00567       /* Compute A = (1 + lmpar) * S_a^{-1} + K_i^T * S_eps^{-1} * K_i ... */
00568       gsl_matrix_memcpy(a, s_a_inv);
00569       gsl_matrix_scale(a, 1 + lmpar);
00570       gsl_matrix_add(a, cov);
```

```
00571
00572       /* Solve A * x_step = b by means of Cholesky decomposition... */
00573       gsl_linalg_cholesky_decomp(a);
00574       gsl_linalg_cholesky_solve(a, b, x_step);
00575
00576       /* Update atmospheric state... */
00577       gsl_vector_add(x_i, x_step);
00578       copy_atm(ctl, atm_i, atm_apr, 0);
00579       copy_obs(ctl, obs_i, obs_meas, 0);
00580       x2atm(ctl, x_i, atm_i);
00581
00582       /* Check atmospheric state... */
00583       for (ip = 0; ip < atm_i->np; ip++) {
00584         atm_i->p[ip] = GSL_MIN(GSL_MAX(atm_i->p[ip], 5e-7), 5e4);
00585         atm_i->t[ip] = GSL_MIN(GSL_MAX(atm_i->t[ip], 100), 400);
00586         for (ig = 0; ig < ctl->ng; ig++)
00587           atm_i->q[ig][ip] = GSL_MIN(GSL_MAX(atm_i->q[ig][ip], 0), 1);
00588         for (iw = 0; iw < ctl->nw; iw++)
00589           atm_i->k[iw][ip] = GSL_MAX(atm_i->k[iw][ip], 0);
00590       }
00591
00592       /* Forward calculation... */
00593       formod(ctl, atm_i, obs_i);
00594       obs2y(ctl, obs_i, y_i, NULL, NULL);
00595
00596       /* Determine dx = x_i - x_a and dy = y - F(x_i) ... */
00597       gsl_vector_memcpy(dx, x_i);
00598       gsl_vector_sub(dx, x_a);
00599       gsl_vector_memcpy(dy, y_m);
00600       gsl_vector_sub(dy, y_i);
00601
00602       /* Compute cost function... */
00603       chisq = cost_function(dx, dy, s_a_inv, sig_eps_inv);
00604
00605       /* Modify Levenberg-Marquardt parameter... */
00606       if (chisq > chisq_old) {
00607         lmpar *= 10;
00608         gsl_vector_sub(x_i, x_step);
00609       } else {
00610         lmpar /= 10;
00611         break;
00612       }
00613     }
00614
00615     /* Write info... */
00616     printf("it= %d / chi^2/m= %g\n", it, chisq);
00617
00618     /* Write to cost function file... */
00619     fprintf(out, "%d %g %d %d\n", it, chisq, (int) m, (int) n);
00620
00621     /* Get normalized step size in state space... */
00622     gsl_blas_ddot(x_step, b, &disq);
00623     disq /= (double) n;
00624
00625     /* Convergence test... */
00626     if ((it == 1 || it % ret->kernel_recomp == 0) && disq < ret->
    conv_dmin)
00627       break;
00628   }
00629
00630   /* Close cost function file... */
00631   fclose(out);
00632
00633   /* Store results... */
00634   write_atm(ret->dir, "atm_final.tab", ctl, atm_i);
00635   write_obs(ret->dir, "obs_final.tab", ctl, obs_i);
00636   write_matrix(ret->dir, "matrix_kernel.tab", ctl, k_i,
00637                atm_i, obs_i, "y", "x", "r");
00638
00639   /* ------------------------------------------------------------
00640      Analysis of retrieval results...
00641      ------------------------------------------------------------ */
00642
00643   /* Check if error analysis is requested... */
00644   if (ret->err_ana) {
00645
00646     /* Allocate... */
00647     auxnm = gsl_matrix_alloc(n, m);
00648     corr = gsl_matrix_alloc(n, n);
00649     gain = gsl_matrix_alloc(n, m);
00650
00651     /* Compute inverse retrieval covariance...
00652        cov^{-1} = S_a^{-1} + K_i^T * S_eps^{-1} * K_i */
00653     matrix_product(k_i, sig_eps_inv, 1, cov);
00654     gsl_matrix_add(cov, s_a_inv);
00655
00656     /* Compute retrieval covariance... */
```

```
00657     matrix_invert(cov);
00658     write_matrix(ret->dir, "matrix_cov_ret.tab", ctl, cov,
00659                  atm_i, obs_i, "x", "x", "r");
00660     write_stddev("total", ret, ctl, atm_i, cov);
00661
00662     /* Compute correlation matrix... */
00663     for (i = 0; i < n; i++)
00664       for (j = 0; j < n; j++)
00665         gsl_matrix_set(corr, i, j, gsl_matrix_get(cov, i, j)
00666                        / sqrt(gsl_matrix_get(cov, i, i))
00667                        / sqrt(gsl_matrix_get(cov, j, j)));
00668     write_matrix(ret->dir, "matrix_corr.tab", ctl, corr,
00669                  atm_i, obs_i, "x", "x", "r");
00670
00671     /* Compute gain matrix...
00672        G = cov * K^T * S_eps^{-1} */
00673     for (i = 0; i < n; i++)
00674       for (j = 0; j < m; j++)
00675         gsl_matrix_set(auxnm, i, j, gsl_matrix_get(k_i, j, i)
00676                        * POW2(gsl_vector_get(sig_eps_inv, j)));
00677     gsl_blas_dgemm(CblasNoTrans, CblasNoTrans, 1.0, cov, auxnm, 0.0, gain);
00678     write_matrix(ret->dir, "matrix_gain.tab", ctl, gain,
00679                  atm_i, obs_i, "x", "y", "c");
00680
00681     /* Compute retrieval error due to noise... */
00682     matrix_product(gain, sig_noise, 2, a);
00683     write_stddev("noise", ret, ctl, atm_i, a);
00684
00685     /* Compute retrieval error  due to forward model errors... */
00686     matrix_product(gain, sig_formod, 2, a);
00687     write_stddev("formod", ret, ctl, atm_i, a);
00688
00689     /* Compute averaging kernel matrix
00690        A = G * K ... */
00691     gsl_blas_dgemm(CblasNoTrans, CblasNoTrans, 1.0, gain, k_i, 0.0, a);
00692     write_matrix(ret->dir, "matrix_avk.tab", ctl, a,
00693                  atm_i, obs_i, "x", "x", "r");
00694
00695     /* Analyze averaging kernel matrix... */
00696     analyze_avk(ret, ctl, atm_i, iqa, ipa, a);
00697
00698     /* Free... */
00699     gsl_matrix_free(auxnm);
00700     gsl_matrix_free(corr);
00701     gsl_matrix_free(gain);
00702   }
00703
00704   /* ------------------------------------------------------------
00705      Finalize...
00706      ------------------------------------------------------------ */
00707
00708   gsl_matrix_free(a);
00709   gsl_matrix_free(cov);
00710   gsl_matrix_free(k_i);
00711   gsl_matrix_free(s_a_inv);
00712
00713   gsl_vector_free(b);
00714   gsl_vector_free(dx);
00715   gsl_vector_free(dy);
00716   gsl_vector_free(sig_eps_inv);
00717   gsl_vector_free(sig_formod);
00718   gsl_vector_free(sig_noise);
00719   gsl_vector_free(x_a);
00720   gsl_vector_free(x_i);
00721   gsl_vector_free(x_step);
00722   gsl_vector_free(y_aux);
00723   gsl_vector_free(y_i);
00724   gsl_vector_free(y_m);
00725 }
```

Here is the call graph for this function:



5.27.2.7 void read_ret (int *argc*, char ∗ *argv[ ]*, ctl_t ∗ *ctl*, ret_t ∗ *ret*)

Read retrieval control parameters.

Definition at line 729 of file retrieval.c.

```
00733               {
00734
00735   int id, ig, iw;
00736
00737   /* Iteration control... */
00738   ret->kernel_recomp =
00739     (int) scan_ctl(argc, argv, "KERNEL_RECOMP", -1, "3", NULL);
00740   ret->conv_itmax = (int) scan_ctl(argc, argv, "CONV_ITMAX", -1, "30", NULL);
00741   ret->conv_dmin = scan_ctl(argc, argv, "CONV_DMIN", -1, "0.1", NULL);
00742
00743   /* Error analysis... */
00744   ret->err_ana = (int) scan_ctl(argc, argv, "ERR_ANA", -1, "1", NULL);
00745
00746   for (id = 0; id < ctl->nd; id++)
00747     ret->err_formod[id] = scan_ctl(argc, argv, "ERR_FORMOD", id, "0", NULL);
00748
00749   for (id = 0; id < ctl->nd; id++)
00750     ret->err_noise[id] = scan_ctl(argc, argv, "ERR_NOISE", id, "0", NULL);
00751
00752   ret->err_press = scan_ctl(argc, argv, "ERR_PRESS", -1, "0", NULL);
00753   ret->err_press_cz = scan_ctl(argc, argv, "ERR_PRESS_CZ", -1, "-999", NULL);
00754   ret->err_press_ch = scan_ctl(argc, argv, "ERR_PRESS_CH", -1, "-999", NULL);
00755
```

```
00756   ret->err_temp = scan_ctl(argc, argv, "ERR_TEMP", -1, "0", NULL);
00757   ret->err_temp_cz = scan_ctl(argc, argv, "ERR_TEMP_CZ", -1, "-999", NULL);
00758   ret->err_temp_ch = scan_ctl(argc, argv, "ERR_TEMP_CH", -1, "-999", NULL);
00759
00760   for (ig = 0; ig < ctl->ng; ig++) {
00761     ret->err_q[ig] = scan_ctl(argc, argv, "ERR_Q", ig, "0", NULL);
00762     ret->err_q_cz[ig] = scan_ctl(argc, argv, "ERR_Q_CZ", ig, "-999", NULL);
00763     ret->err_q_ch[ig] = scan_ctl(argc, argv, "ERR_Q_CH", ig, "-999", NULL);
00764   }
00765
00766   for (iw = 0; iw < ctl->nw; iw++) {
00767     ret->err_k[iw] = scan_ctl(argc, argv, "ERR_K", iw, "0", NULL);
00768     ret->err_k_cz[iw] = scan_ctl(argc, argv, "ERR_K_CZ", iw, "-999", NULL);
00769     ret->err_k_ch[iw] = scan_ctl(argc, argv, "ERR_K_CH", iw, "-999", NULL);
00770   }
00771 }
```

Here is the call graph for this function:

5.27.2.8 void set_cov_apr (ret_t * *ret*, ctl_t * *ctl*, atm_t * *atm*, int * *iqa*, int * *ipa*, gsl_matrix * *s_a*)

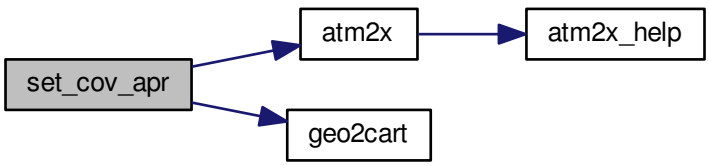
Set a priori covariance.

Definition at line 775 of file retrieval.c.

```
00781                   {
00782
00783   gsl_vector *x_a;
00784
00785   double ch, cz, rho, x0[3], x1[3];
00786
00787   int ig, iw;
00788
00789   size_t i, j, n;
00790
00791   /* Get sizes... */
00792   n = s_a->size1;
00793
00794   /* Allocate... */
00795   x_a = gsl_vector_alloc(n);
00796
00797   /* Get sigma vector... */
00798   atm2x(ctl, atm, x_a, NULL, NULL);
00799   for (i = 0; i < n; i++) {
00800     if (iqa[i] == IDXP)
00801       gsl_vector_set(x_a, i, ret->err_press / 100 * gsl_vector_get(x_a, i));
00802     if (iqa[i] == IDXT)
00803       gsl_vector_set(x_a, i, ret->err_temp);
00804     for (ig = 0; ig < ctl->ng; ig++)
00805       if (iqa[i] == IDXQ(ig))
00806         gsl_vector_set(x_a, i, ret->err_q[ig] / 100 * gsl_vector_get(x_a, i));
00807     for (iw = 0; iw < ctl->nw; iw++)
00808       if (iqa[i] == IDXK(iw))
00809         gsl_vector_set(x_a, i, ret->err_k[iw]);
00810   }
00811
00812   /* Check standard deviations... */
00813   for (i = 0; i < n; i++)
00814     if (POW2(gsl_vector_get(x_a, i)) <= 0)
00815       ERRMSG("Check a priori data (zero standard deviation)!");
00816
00817   /* Initialize diagonal covariance... */
```

```
00818   gsl_matrix_set_zero(s_a);
00819   for (i = 0; i < n; i++)
00820     gsl_matrix_set(s_a, i, i, POW2(gsl_vector_get(x_a, i)));
00821
00822   /* Loop over matrix elements... */
00823   for (i = 0; i < n; i++)
00824     for (j = 0; j < n; j++)
00825       if (i != j && iqa[i] == iqa[j]) {
00826
00827         /* Initialize... */
00828         cz = ch = 0;
00829
00830         /* Set correlation lengths for pressure... */
00831         if (iqa[i] == IDXP) {
00832           cz = ret->err_press_cz;
00833           ch = ret->err_press_ch;
00834         }
00835
00836         /* Set correlation lengths for temperature... */
00837         if (iqa[i] == IDXT) {
00838           cz = ret->err_temp_cz;
00839           ch = ret->err_temp_ch;
00840         }
00841
00842         /* Set correlation lengths for volume mixing ratios... */
00843         for (ig = 0; ig < ctl->ng; ig++)
00844           if (iqa[i] == IDXQ(ig)) {
00845             cz = ret->err_q_cz[ig];
00846             ch = ret->err_q_ch[ig];
00847           }
00848
00849         /* Set correlation lengths for extinction... */
00850         for (iw = 0; iw < ctl->nw; iw++)
00851           if (iqa[i] == IDXK(iw)) {
00852             cz = ret->err_k_cz[iw];
00853             ch = ret->err_k_ch[iw];
00854           }
00855
00856         /* Compute correlations... */
00857         if (cz > 0 && ch > 0) {
00858
00859           /* Get Cartesian coordinates... */
00860           geo2cart(0, atm->lon[ipa[i]], atm->lat[ipa[i]], x0);
00861           geo2cart(0, atm->lon[ipa[j]], atm->lat[ipa[j]], x1);
00862
00863           /* Compute correlations... */
00864           rho =
00865             exp(-DIST(x0, x1) / ch -
00866                 fabs(atm->z[ipa[i]] - atm->z[ipa[j]]) / cz);
00867
00868           /* Set covariance... */
00869           gsl_matrix_set(s_a, i, j, gsl_vector_get(x_a, i)
00870                          * gsl_vector_get(x_a, j) * rho);
00871         }
00872       }
00873
00874   /* Free... */
00875   gsl_vector_free(x_a);
00876 }
```

Here is the call graph for this function:



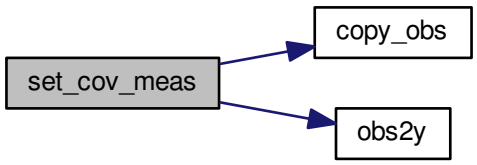
5.27.2.9 void set_cov_meas (ret_t * *ret*, ctl_t * *ctl*, obs_t * *obs*, gsl_vector * *sig_noise*, gsl_vector * *sig_formod*, gsl_vector * *sig_eps_inv*)

Set measurement errors.

Definition at line 880 of file retrieval.c.

```
00886                           {
00887
00888   static obs_t obs_err;
00889
00890   int id, ir;
00891
00892   size_t i, m;
00893
00894   /* Get size... */
00895   m = sig_eps_inv->size;
00896
00897   /* Noise error (always considered in retrieval fit)... */
00898   copy_obs(ctl, &obs_err, obs, 1);
00899   for (ir = 0; ir < obs_err.nr; ir++)
00900     for (id = 0; id < ctl->nd; id++)
00901       obs_err.rad[id][ir]
00902         = (gsl_finite(obs->rad[id][ir]) ? ret->err_noise[id] : GSL_NAN);
00903   obs2y(ctl, &obs_err, sig_noise, NULL, NULL);
00904
00905   /* Forward model error (always considered in retrieval fit)... */
00906   copy_obs(ctl, &obs_err, obs, 1);
00907   for (ir = 0; ir < obs_err.nr; ir++)
00908     for (id = 0; id < ctl->nd; id++)
00909       obs_err.rad[id][ir]
00910         = fabs(ret->err_formod[id] / 100 * obs->rad[id][ir]);
00911   obs2y(ctl, &obs_err, sig_formod, NULL, NULL);
00912
00913   /* Total error... */
00914   for (i = 0; i < m; i++)
00915     gsl_vector_set(sig_eps_inv, i, 1 / sqrt(POW2(gsl_vector_get(sig_noise, i))
00916                                             +
00917                                             POW2(gsl_vector_get
00918                                                  (sig_formod, i))));
00919
00920   /* Check standard deviations... */
00921   for (i = 0; i < m; i++)
00922     if (gsl_vector_get(sig_eps_inv, i) <= 0)
00923       ERRMSG("Check measurement errors (zero standard deviation)!");
00924 }
```

Here is the call graph for this function:



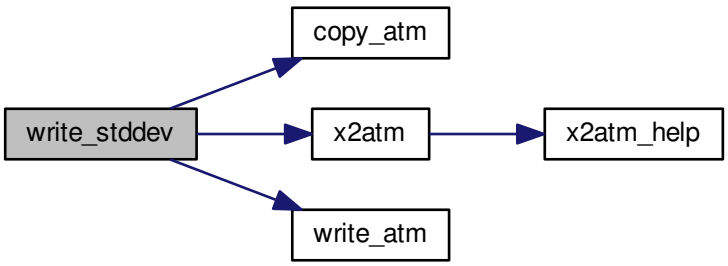
5.27.2.10 void write_stddev (const char * *quantity*, ret_t * *ret*, ctl_t * *ctl*, atm_t * *atm*, gsl_matrix * *s*)

Write retrieval error to file.

Definition at line 928 of file retrieval.c.

```
00933                  {
00934
00935   static atm_t atm_aux;
00936
00937   gsl_vector *x_aux;
00938
00939   char filename[LEN];
00940
00941   size_t i, n;
00942
00943   /* Get sizes... */
00944   n = s->size1;
00945
00946   /* Allocate... */
00947   x_aux = gsl_vector_alloc(n);
00948
00949   /* Compute standard deviation... */
00950   for (i = 0; i < n; i++)
00951     gsl_vector_set(x_aux, i, sqrt(gsl_matrix_get(s, i, i)));
00952
00953   /* Write to disk... */
00954   copy_atm(ctl, &atm_aux, atm, 1);
00955   x2atm(ctl, x_aux, &atm_aux);
00956   sprintf(filename, "atm_err_%s.tab", quantity);
00957   write_atm(ret->dir, filename, ctl, &atm_aux);
00958
00959   /* Free... */
00960   gsl_vector_free(x_aux);
00961 }
```

Here is the call graph for this function:



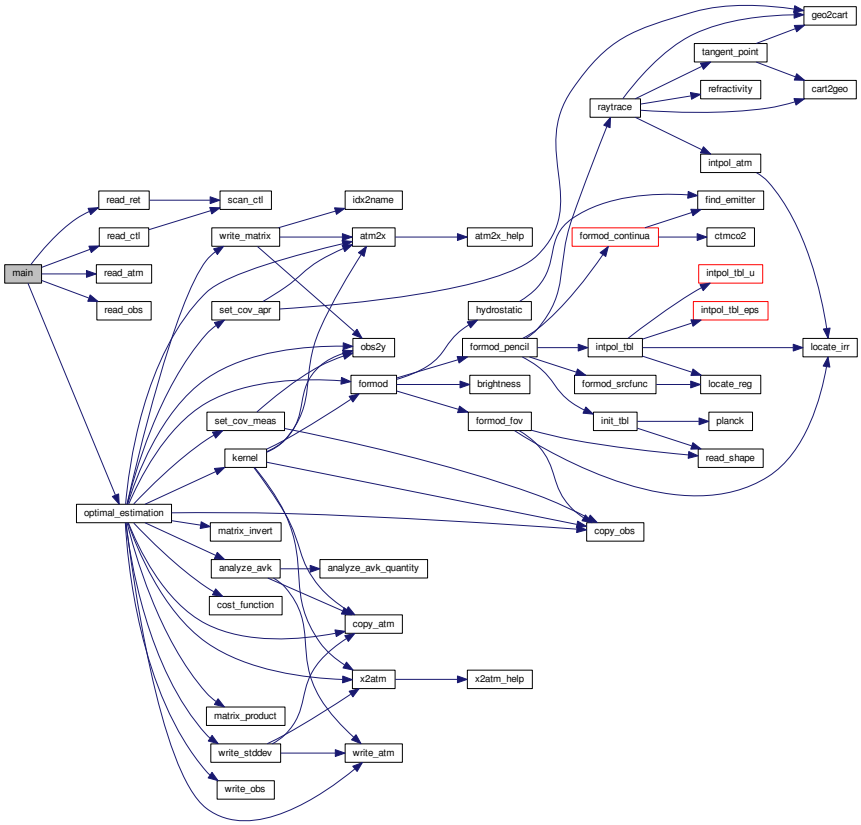
5.27.2.11 int main (int *argc*, char * *argv[ ]*)

Definition at line 180 of file retrieval.c.

```
00182                  {
00183
00184   static atm_t atm_i, atm_apr;
00185   static ctl_t ctl;
00186   static obs_t obs_i, obs_meas;
00187   static ret_t ret;
00188
00189   FILE *dirlist;
00190
00191   /* Check arguments... */
00192   if (argc < 3)
00193     ERRMSG("Give parameters: <ctl> <dirlist>");
00194
00195   /* Measure CPU-time... */
00196   TIMER("total", 1);
00197
00198   /* Read control parameters... */
00199   read_ctl(argc, argv, &ctl);
```

```
00200   read_ret(argc, argv, &ctl, &ret);
00201
00202   /* Open directory list... */
00203   if (!(dirlist = fopen(argv[2], "r")))
00204     ERRMSG("Cannot open directory list!");
00205
00206   /* Loop over directories... */
00207   while (fscanf(dirlist, "%s", ret.dir) != EOF) {
00208
00209     /* Write info... */
00210     printf("\nRetrieve in directory %s...\n\n", ret.dir);
00211
00212     /* Read atmospheric data... */
00213     read_atm(ret.dir, "atm_apr.tab", &ctl, &atm_apr);
00214
00215     /* Read observation data... */
00216     read_obs(ret.dir, "obs_meas.tab", &ctl, &obs_meas);
00217
00218     /* Run retrieval... */
00219     optimal_estimation(&ret, &ctl, &obs_meas, &obs_i, &atm_apr, &atm_i);
00220
00221     /* Measure CPU-time... */
00222     TIMER("total", 2);
00223   }
00224
00225   /* Write info... */
00226   printf("\nRetrieval done...\n");
00227
00228   /* Measure CPU-time... */
00229   TIMER("total", 3);
00230
00231   return EXIT_SUCCESS;
00232 }
```

Here is the call graph for this function:



5.28 retrieval.c

```
00001 /*
```

```
00002   This file is part of JURASSIC.
00003
00004   JURASSIC is free software: you can redistribute it and/or modify
00005   it under the terms of the GNU General Public License as published by
00006   the Free Software Foundation, either version 3 of the License, or
00007   (at your option) any later version.
00008
00009   JURASSIC is distributed in the hope that it will be useful,
00010   but WITHOUT ANY WARRANTY; without even the implied warranty of
00011   MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.  See the
00012   GNU General Public License for more details.
00013
00014   You should have received a copy of the GNU General Public License
00015   along with JURASSIC. If not, see <http://www.gnu.org/licenses/>.
00016
00017   Copright (C) 2003-2015 Forschungszentrum Juelich GmbH
00018 */
00019
00025 #include "jurassic.h"
00026
00027 /* ------------------------------------------------------------
00028    Structs...
00029    ------------------------------------------------------------ */
00030
00032 typedef struct {
00033
00035   char dir[LEN];
00036
00038   int kernel_recomp;
00039
00041   int conv_itmax;
00042
00044   double conv_dmin;
00045
00047   int err_ana;
00048
00050   double err_formod[ND];
00051
00053   double err_noise[ND];
00054
00056   double err_press;
00057
00059   double err_press_cz;
00060
00062   double err_press_ch;
00063
00065   double err_temp;
00066
00068   double err_temp_cz;
00069
00071   double err_temp_ch;
00072
00074   double err_q[NG];
00075
00077   double err_q_cz[NG];
00078
00080   double err_q_ch[NG];
00081
00083   double err_k[NW];
00084
00086   double err_k_cz[NW];
00087
00089   double err_k_ch[NW];
00090
00091 } ret_t;
00092
00093 /* ------------------------------------------------------------
00094    Functions...
00095    ------------------------------------------------------------ */
00096
00098 void analyze_avk(
00099   ret_t * ret,
00100   ctl_t * ctl,
00101   atm_t * atm,
00102   int *iqa,
00103   int *ipa,
00104   gsl_matrix * avk);
00105
00107 void analyze_avk_quantity(
00108   gsl_matrix * avk,
00109   int iq,
00110   int *ipa,
00111   size_t * n0,
00112   size_t * n1,
00113   double *cont,
00114   double *res);
00115
```

```
00117 double cost_function(
00118   gsl_vector * dx,
00119   gsl_vector * dy,
00120   gsl_matrix * s_a_inv,
00121   gsl_vector * sig_eps_inv);
00122
00124 void matrix_invert(
00125   gsl_matrix * a);
00126
00128 void matrix_product(
00129   gsl_matrix * a,
00130   gsl_vector * b,
00131   int transpose,
00132   gsl_matrix * c);
00133
00135 void optimal_estimation(
00136   ret_t * ret,
00137   ctl_t * ctl,
00138   obs_t * obs_meas,
00139   obs_t * obs_i,
00140   atm_t * atm_apr,
00141   atm_t * atm_i);
00142
00144 void read_ret(
00145   int argc,
00146   char *argv[],
00147   ctl_t * ctl,
00148   ret_t * ret);
00149
00151 void set_cov_apr(
00152   ret_t * ret,
00153   ctl_t * ctl,
00154   atm_t * atm,
00155   int *iqa,
00156   int *ipa,
00157   gsl_matrix * s_a);
00158
00160 void set_cov_meas(
00161   ret_t * ret,
00162   ctl_t * ctl,
00163   obs_t * obs,
00164   gsl_vector * sig_noise,
00165   gsl_vector * sig_formod,
00166   gsl_vector * sig_eps_inv);
00167
00169 void write_stddev(
00170   const char *quantity,
00171   ret_t * ret,
00172   ctl_t * ctl,
00173   atm_t * atm,
00174   gsl_matrix * s);
00175
00176 /* ------------------------------------------------------------
00177    Main...
00178    ------------------------------------------------------------ */
00179
00180 int main(
00181   int argc,
00182   char *argv[]) {
00183
00184   static atm_t atm_i, atm_apr;
00185   static ctl_t ctl;
00186   static obs_t obs_i, obs_meas;
00187   static ret_t ret;
00188
00189   FILE *dirlist;
00190
00191   /* Check arguments... */
00192   if (argc < 3)
00193     ERRMSG("Give parameters: <ctl> <dirlist>");
00194
00195   /* Measure CPU-time... */
00196   TIMER("total", 1);
00197
00198   /* Read control parameters... */
00199   read_ctl(argc, argv, &ctl);
00200   read_ret(argc, argv, &ctl, &ret);
00201
00202   /* Open directory list... */
00203   if (!(dirlist = fopen(argv[2], "r")))
00204     ERRMSG("Cannot open directory list!");
00205
00206   /* Loop over directories... */
00207   while (fscanf(dirlist, "%s", ret.dir) != EOF) {
00208
00209     /* Write info... */
00210     printf("\nRetrieve in directory %s...\n\n", ret.dir);
```

```
00211
00212     /* Read atmospheric data... */
00213     read_atm(ret.dir, "atm_apr.tab", &ctl, &atm_apr);
00214
00215     /* Read observation data... */
00216     read_obs(ret.dir, "obs_meas.tab", &ctl, &obs_meas);
00217
00218     /* Run retrieval... */
00219     optimal_estimation(&ret, &ctl, &obs_meas, &obs_i, &atm_apr, &atm_i);
00220
00221     /* Measure CPU-time... */
00222     TIMER("total", 2);
00223   }
00224
00225   /* Write info... */
00226   printf("\nRetrieval done...\n");
00227
00228   /* Measure CPU-time... */
00229   TIMER("total", 3);
00230
00231   return EXIT_SUCCESS;
00232 }
00233
00234 /*****************************************************************************/
00235
00236 void analyze_avk(
00237   ret_t * ret,
00238   ctl_t * ctl,
00239   atm_t * atm,
00240   int *iqa,
00241   int *ipa,
00242   gsl_matrix * avk) {
00243
00244   static atm_t atm_cont, atm_res;
00245
00246   int ig, iq, iw;
00247
00248   size_t i, n, n0[NQ], n1[NQ];
00249
00250   /* Get sizes... */
00251   n = avk->size1;
00252
00253   /* Find sub-matrices for different quantities... */
00254   for (iq = 0; iq < NQ; iq++) {
00255     n0[iq] = N;
00256     for (i = 0; i < n; i++) {
00257       if (iqa[i] == iq && n0[iq] == N)
00258         n0[iq] = i;
00259       if (iqa[i] == iq)
00260         n1[iq] = i - n0[iq] + 1;
00261     }
00262   }
00263
00264   /* Initialize... */
00265   copy_atm(ctl, &atm_cont, atm, 1);
00266   copy_atm(ctl, &atm_res, atm, 1);
00267
00268   /* Analyze quantities... */
00269   analyze_avk_quantity(avk, IDXP, ipa, n0, n1, atm_cont.p, atm_res.
      p);
00270   analyze_avk_quantity(avk, IDXT, ipa, n0, n1, atm_cont.t, atm_res.
      t);
00271   for (ig = 0; ig < ctl->ng; ig++)
00272     analyze_avk_quantity(avk, IDXQ(ig), ipa, n0, n1,
00273                          atm_cont.q[ig], atm_res.q[ig]);
00274   for (iw = 0; iw < ctl->nw; iw++)
00275     analyze_avk_quantity(avk, IDXK(iw), ipa, n0, n1,
00276                          atm_cont.k[iw], atm_res.k[iw]);
00277
00278   /* Write results to disk... */
00279   write_atm(ret->dir, "atm_cont.tab", ctl, &atm_cont);
00280   write_atm(ret->dir, "atm_res.tab", ctl, &atm_res);
00281 }
00282
00283 /*****************************************************************************/
00284
00285 void analyze_avk_quantity(
00286   gsl_matrix * avk,
00287   int iq,
00288   int *ipa,
00289   size_t * n0,
00290   size_t * n1,
00291   double *cont,
00292   double *res) {
00293
00294   size_t i, j;
00295
```

```
00296   /* Loop over state vector elements... */
00297   if (n0[iq] < N)
00298     for (i = 0; i < n1[iq]; i++) {
00299
00300       /* Get area of averagig kernel... */
00301       for (j = 0; j < n1[iq]; j++)
00302         cont[ipa[n0[iq] + i]] += gsl_matrix_get(avk, n0[iq] + i, n0[iq] + j);
00303
00304       /* Get information density... */
00305       res[ipa[n0[iq] + i]] = 1 / gsl_matrix_get(avk, n0[iq] + i, n0[iq] + i);
00306     }
00307 }
00308
00309 /*****************************************************************************/
00310
00311 double cost_function(
00312   gsl_vector * dx,
00313   gsl_vector * dy,
00314   gsl_matrix * s_a_inv,
00315   gsl_vector * sig_eps_inv) {
00316
00317   gsl_vector *x_aux, *y_aux;
00318
00319   double chisq_a, chisq_m = 0;
00320
00321   size_t i, m, n;
00322
00323   /* Get sizes... */
00324   m = dy->size;
00325   n = dx->size;
00326
00327   /* Allocate... */
00328   x_aux = gsl_vector_alloc(n);
00329   y_aux = gsl_vector_alloc(m);
00330
00331   /* Determine normalized cost function...
00332      (chi^2 = 1/m * [dy^T * S_eps^{-1} * dy + dx^T * S_a^{-1} * dx]) */
00333   for (i = 0; i < m; i++)
00334     chisq_m += POW2(gsl_vector_get(dy, i) * gsl_vector_get(sig_eps_inv, i));
00335   gsl_blas_dgemv(CblasNoTrans, 1.0, s_a_inv, dx, 0.0, x_aux);
00336   gsl_blas_ddot(dx, x_aux, &chisq_a);
00337
00338   /* Free... */
00339   gsl_vector_free(x_aux);
00340   gsl_vector_free(y_aux);
00341
00342   /* Return cost function value... */
00343   return (chisq_m + chisq_a) / (double) m;
00344 }
00345
00346 /*****************************************************************************/
00347
00348 void matrix_invert(
00349   gsl_matrix * a) {
00350
00351   size_t diag = 1, i, j, n;
00352
00353   /* Get size... */
00354   n = a->size1;
00355
00356   /* Check if matrix is diagonal... */
00357   for (i = 0; i < n && diag; i++)
00358     for (j = i + 1; j < n; j++)
00359       if (gsl_matrix_get(a, i, j) != 0) {
00360         diag = 0;
00361         break;
00362       }
00363
00364   /* Quick inversion of diagonal matrix... */
00365   if (diag)
00366     for (i = 0; i < n; i++)
00367       gsl_matrix_set(a, i, i, 1 / gsl_matrix_get(a, i, i));
00368
00369   /* Matrix inversion by means of Cholesky decomposition... */
00370   else {
00371     gsl_linalg_cholesky_decomp(a);
00372     gsl_linalg_cholesky_invert(a);
00373   }
00374 }
00375
00376 /*****************************************************************************/
00377
00378 void matrix_product(
00379   gsl_matrix * a,
00380   gsl_vector * b,
00381   int transpose,
00382   gsl_matrix * c) {
```

```
00383
00384   gsl_matrix *aux;
00385
00386   size_t i, j, m, n;
00387
00388   /* Set sizes... */
00389   m = a->size1;
00390   n = a->size2;
00391
00392   /* Allocate... */
00393   aux = gsl_matrix_alloc(m, n);
00394
00395   /* Compute A^T B A... */
00396   if (transpose == 1) {
00397
00398     /* Compute B^1/2 A... */
00399     for (i = 0; i < m; i++)
00400       for (j = 0; j < n; j++)
00401         gsl_matrix_set(aux, i, j,
00402                        gsl_vector_get(b, i) * gsl_matrix_get(a, i, j));
00403
00404     /* Compute A^T B A = (B^1/2 A)^T (B^1/2 A)... */
00405     gsl_blas_dgemm(CblasTrans, CblasNoTrans, 1.0, aux, aux, 0.0, c);
00406   }
00407
00408   /* Compute A B A^T... */
00409   else if (transpose == 2) {
00410
00411     /* Compute A B^1/2... */
00412     for (i = 0; i < m; i++)
00413       for (j = 0; j < n; j++)
00414         gsl_matrix_set(aux, i, j,
00415                        gsl_matrix_get(a, i, j) * gsl_vector_get(b, j));
00416
00417     /* Compute A B A^T = (A B^1/2) (A B^1/2)^T... */
00418     gsl_blas_dgemm(CblasNoTrans, CblasTrans, 1.0, aux, aux, 0.0, c);
00419   }
00420
00421   /* Free... */
00422   gsl_matrix_free(aux);
00423 }
00424
00425 /*****************************************************************************/
00426
00427 void optimal_estimation(
00428   ret_t * ret,
00429   ctl_t * ctl,
00430   obs_t * obs_meas,
00431   obs_t * obs_i,
00432   atm_t * atm_apr,
00433   atm_t * atm_i) {
00434
00435   static int ipa[N], iqa[N];
00436
00437   gsl_matrix *a, *auxnm, *corr, *cov, *gain, *k_i, *s_a_inv;
00438   gsl_vector *b, *dx, *dy, *sig_eps_inv, *sig_formod, *sig_noise,
00439     *x_a, *x_i, *x_step, *y_aux, *y_i, *y_m;
00440
00441   FILE *out;
00442
00443   char filename[LEN];
00444
00445   double chisq, chisq_old, disq = 0, lmpar = 0.001;
00446
00447   int ig, ip, it = 0, it2, iw;
00448
00449   size_t i, j, m, n;
00450
00451   /* ------------------------------------------------------------
00452      Initialize...
00453      ------------------------------------------------------------ */
00454
00455   /* Get sizes... */
00456   m = obs2y(ctl, obs_meas, NULL, NULL, NULL);
00457   n = atm2x(ctl, atm_apr, NULL, iqa, ipa);
00458   if (m <= 0 || n <= 0)
00459     ERRMSG("Check problem definition!");
00460
00461   /* Write info... */
00462   printf("Problem size: m= %d / n= %d "
00463          "(alloc= %.4g MB / stat= %.4g MB)\n",
00464          (int) m, (int) n,
00465          (double) (3 * m * n + 4 * n * n + 8 * m +
00466                    8 * n) * sizeof(double) / 1024. / 1024.,
00467          (double) (5 * sizeof(atm_t) + 3 * sizeof(obs_t)
00468                    + 2 * N * sizeof(int)) / 1024. / 1024.);
00469
```

```
00470   /* Allocate... */
00471   a = gsl_matrix_alloc(n, n);
00472   cov = gsl_matrix_alloc(n, n);
00473   k_i = gsl_matrix_alloc(m, n);
00474   s_a_inv = gsl_matrix_alloc(n, n);
00475
00476   b = gsl_vector_alloc(n);
00477   dx = gsl_vector_alloc(n);
00478   dy = gsl_vector_alloc(m);
00479   sig_eps_inv = gsl_vector_alloc(m);
00480   sig_formod = gsl_vector_alloc(m);
00481   sig_noise = gsl_vector_alloc(m);
00482   x_a = gsl_vector_alloc(n);
00483   x_i = gsl_vector_alloc(n);
00484   x_step = gsl_vector_alloc(n);
00485   y_aux = gsl_vector_alloc(m);
00486   y_i = gsl_vector_alloc(m);
00487   y_m = gsl_vector_alloc(m);
00488
00489   /* Set initial state... */
00490   copy_atm(ctl, atm_i, atm_apr, 0);
00491   copy_obs(ctl, obs_i, obs_meas, 0);
00492   formod(ctl, atm_i, obs_i);
00493
00494   /* Set state vectors and observation vectors... */
00495   atm2x(ctl, atm_apr, x_a, NULL, NULL);
00496   atm2x(ctl, atm_i, x_i, NULL, NULL);
00497   obs2y(ctl, obs_meas, y_m, NULL, NULL);
00498   obs2y(ctl, obs_i, y_i, NULL, NULL);
00499
00500   /* Set inverse a priori covariance S_a^-1... */
00501   set_cov_apr(ret, ctl, atm_apr, iqa, ipa, s_a_inv);
00502   write_matrix(ret->dir, "matrix_cov_apr.tab", ctl, s_a_inv,
00503                atm_i, obs_i, "x", "x", "r");
00504   matrix_invert(s_a_inv);
00505
00506   /* Get measurement errors... */
00507   set_cov_meas(ret, ctl, obs_meas, sig_noise, sig_formod, sig_eps_inv);
00508
00509   /* Create cost function file... */
00510   sprintf(filename, "%s/costs.tab", ret->dir);
00511   if (!(out = fopen(filename, "w")))
00512     ERRMSG("Cannot create cost function file!");
00513
00514   /* Write header... */
00515   fprintf(out,
00516           "# $1 = iteration number\n"
00517           "# $2 = normalized cost function\n"
00518           "# $3 = number of measurements\n"
00519           "# $4 = number of state vector elements\n\n");
00520
00521   /* Determine dx = x_i - x_a and dy = y - F(x_i) ... */
00522   gsl_vector_memcpy(dx, x_i);
00523   gsl_vector_sub(dx, x_a);
00524   gsl_vector_memcpy(dy, y_m);
00525   gsl_vector_sub(dy, y_i);
00526
00527   /* Compute cost function... */
00528   chisq = cost_function(dx, dy, s_a_inv, sig_eps_inv);
00529
00530   /* Write info... */
00531   printf("it= %d / chi^2/m= %g\n", it, chisq);
00532
00533   /* Write to cost function file... */
00534   fprintf(out, "%d %g %d %d\n", it, chisq, (int) m, (int) n);
00535
00536   /* Compute initial kernel... */
00537   kernel(ctl, atm_i, obs_i, k_i);
00538
00539   /* ------------------------------------------------------------
00540      Levenberg-Marquardt minimization...
00541      ------------------------------------------------------------ */
00542
00543   /* Outer loop... */
00544   for (it = 1; it <= ret->conv_itmax; it++) {
00545
00546     /* Store current cost function value... */
00547     chisq_old = chisq;
00548
00549     /* Compute kernel matrix K_i... */
00550     if (it > 1 && it % ret->kernel_recomp == 0)
00551       kernel(ctl, atm_i, obs_i, k_i);
00552
00553     /* Compute K_i^T * S_eps^{-1} * K_i ... */
00554     if (it == 1 || it % ret->kernel_recomp == 0)
00555       matrix_product(k_i, sig_eps_inv, 1, cov);
00556
```

```
00557     /* Determine b = K_i^T * S_eps^{-1} * dy - S_a^{-1} * dx ... */
00558     for (i = 0; i < m; i++)
00559       gsl_vector_set(y_aux, i, gsl_vector_get(dy, i)
00560                      * POW2(gsl_vector_get(sig_eps_inv, i)));
00561     gsl_blas_dgemv(CblasTrans, 1.0, k_i, y_aux, 0.0, b);
00562     gsl_blas_dgemv(CblasNoTrans, -1.0, s_a_inv, dx, 1.0, b);
00563
00564     /* Inner loop... */
00565     for (it2 = 0; it2 < 20; it2++) {
00566
00567       /* Compute A = (1 + lmpar) * S_a^{-1} + K_i^T * S_eps^{-1} * K_i ... */
00568       gsl_matrix_memcpy(a, s_a_inv);
00569       gsl_matrix_scale(a, 1 + lmpar);
00570       gsl_matrix_add(a, cov);
00571
00572       /* Solve A * x_step = b by means of Cholesky decomposition... */
00573       gsl_linalg_cholesky_decomp(a);
00574       gsl_linalg_cholesky_solve(a, b, x_step);
00575
00576       /* Update atmospheric state... */
00577       gsl_vector_add(x_i, x_step);
00578       copy_atm(ctl, atm_i, atm_apr, 0);
00579       copy_obs(ctl, obs_i, obs_meas, 0);
00580       x2atm(ctl, x_i, atm_i);
00581
00582       /* Check atmospheric state... */
00583       for (ip = 0; ip < atm_i->np; ip++) {
00584         atm_i->p[ip] = GSL_MIN(GSL_MAX(atm_i->p[ip], 5e-7), 5e4);
00585         atm_i->t[ip] = GSL_MIN(GSL_MAX(atm_i->t[ip], 100), 400);
00586         for (ig = 0; ig < ctl->ng; ig++)
00587           atm_i->q[ig][ip] = GSL_MIN(GSL_MAX(atm_i->q[ig][ip], 0), 1);
00588         for (iw = 0; iw < ctl->nw; iw++)
00589           atm_i->k[iw][ip] = GSL_MAX(atm_i->k[iw][ip], 0);
00590       }
00591
00592       /* Forward calculation... */
00593       formod(ctl, atm_i, obs_i);
00594       obs2y(ctl, obs_i, y_i, NULL, NULL);
00595
00596       /* Determine dx = x_i - x_a and dy = y - F(x_i) ... */
00597       gsl_vector_memcpy(dx, x_i);
00598       gsl_vector_sub(dx, x_a);
00599       gsl_vector_memcpy(dy, y_m);
00600       gsl_vector_sub(dy, y_i);
00601
00602       /* Compute cost function... */
00603       chisq = cost_function(dx, dy, s_a_inv, sig_eps_inv);
00604
00605       /* Modify Levenberg-Marquardt parameter... */
00606       if (chisq > chisq_old) {
00607         lmpar *= 10;
00608         gsl_vector_sub(x_i, x_step);
00609       } else {
00610         lmpar /= 10;
00611         break;
00612       }
00613     }
00614
00615     /* Write info... */
00616     printf("it= %d / chi^2/m= %g\n", it, chisq);
00617
00618     /* Write to cost function file... */
00619     fprintf(out, "%d %g %d %d\n", it, chisq, (int) m, (int) n);
00620
00621     /* Get normalized step size in state space... */
00622     gsl_blas_ddot(x_step, b, &disq);
00623     disq /= (double) n;
00624
00625     /* Convergence test... */
00626     if ((it == 1 || it % ret->kernel_recomp == 0) && disq < ret->
      conv_dmin)
00627       break;
00628   }
00629
00630   /* Close cost function file... */
00631   fclose(out);
00632
00633   /* Store results... */
00634   write_atm(ret->dir, "atm_final.tab", ctl, atm_i);
00635   write_obs(ret->dir, "obs_final.tab", ctl, obs_i);
00636   write_matrix(ret->dir, "matrix_kernel.tab", ctl, k_i,
00637                atm_i, obs_i, "y", "x", "r");
00638
00639   /* ------------------------------------------------------------
00640      Analysis of retrieval results...
00641      ------------------------------------------------------------ */
00642
```

```
00643   /* Check if error analysis is requested... */
00644   if (ret->err_ana) {
00645
00646     /* Allocate... */
00647     auxnm = gsl_matrix_alloc(n, m);
00648     corr = gsl_matrix_alloc(n, n);
00649     gain = gsl_matrix_alloc(n, m);
00650
00651     /* Compute inverse retrieval covariance...
00652        cov^{-1} = S_a^{-1} + K_i^T * S_eps^{-1} * K_i */
00653     matrix_product(k_i, sig_eps_inv, 1, cov);
00654     gsl_matrix_add(cov, s_a_inv);
00655
00656     /* Compute retrieval covariance... */
00657     matrix_invert(cov);
00658     write_matrix(ret->dir, "matrix_cov_ret.tab", ctl, cov,
00659                  atm_i, obs_i, "x", "x", "r");
00660     write_stddev("total", ret, ctl, atm_i, cov);
00661
00662     /* Compute correlation matrix... */
00663     for (i = 0; i < n; i++)
00664       for (j = 0; j < n; j++)
00665         gsl_matrix_set(corr, i, j, gsl_matrix_get(cov, i, j)
00666                        / sqrt(gsl_matrix_get(cov, i, i))
00667                        / sqrt(gsl_matrix_get(cov, j, j)));
00668     write_matrix(ret->dir, "matrix_corr.tab", ctl, corr,
00669                  atm_i, obs_i, "x", "x", "r");
00670
00671     /* Compute gain matrix...
00672        G = cov * K^T * S_eps^{-1} */
00673     for (i = 0; i < n; i++)
00674       for (j = 0; j < m; j++)
00675         gsl_matrix_set(auxnm, i, j, gsl_matrix_get(k_i, j, i)
00676                        * POW2(gsl_vector_get(sig_eps_inv, j)));
00677     gsl_blas_dgemm(CblasNoTrans, CblasNoTrans, 1.0, cov, auxnm, 0.0, gain);
00678     write_matrix(ret->dir, "matrix_gain.tab", ctl, gain,
00679                  atm_i, obs_i, "x", "y", "c");
00680
00681     /* Compute retrieval error due to noise... */
00682     matrix_product(gain, sig_noise, 2, a);
00683     write_stddev("noise", ret, ctl, atm_i, a);
00684
00685     /* Compute retrieval error  due to forward model errors... */
00686     matrix_product(gain, sig_formod, 2, a);
00687     write_stddev("formod", ret, ctl, atm_i, a);
00688
00689     /* Compute averaging kernel matrix
00690        A = G * K ... */
00691     gsl_blas_dgemm(CblasNoTrans, CblasNoTrans, 1.0, gain, k_i, 0.0, a);
00692     write_matrix(ret->dir, "matrix_avk.tab", ctl, a,
00693                  atm_i, obs_i, "x", "x", "r");
00694
00695     /* Analyze averaging kernel matrix... */
00696     analyze_avk(ret, ctl, atm_i, iqa, ipa, a);
00697
00698     /* Free... */
00699     gsl_matrix_free(auxnm);
00700     gsl_matrix_free(corr);
00701     gsl_matrix_free(gain);
00702   }
00703
00704   /* ------------------------------------------------------------
00705      Finalize...
00706      ------------------------------------------------------------ */
00707
00708   gsl_matrix_free(a);
00709   gsl_matrix_free(cov);
00710   gsl_matrix_free(k_i);
00711   gsl_matrix_free(s_a_inv);
00712
00713   gsl_vector_free(b);
00714   gsl_vector_free(dx);
00715   gsl_vector_free(dy);
00716   gsl_vector_free(sig_eps_inv);
00717   gsl_vector_free(sig_formod);
00718   gsl_vector_free(sig_noise);
00719   gsl_vector_free(x_a);
00720   gsl_vector_free(x_i);
00721   gsl_vector_free(x_step);
00722   gsl_vector_free(y_aux);
00723   gsl_vector_free(y_i);
00724   gsl_vector_free(y_m);
00725 }
00726
00727 /*****************************************************************************/
00728
00729 void read_ret(
```

```
00730   int argc,
00731   char *argv[],
00732   ctl_t * ctl,
00733   ret_t * ret) {
00734
00735   int id, ig, iw;
00736
00737   /* Iteration control... */
00738   ret->kernel_recomp =
00739     (int) scan_ctl(argc, argv, "KERNEL_RECOMP", -1, "3", NULL);
00740   ret->conv_itmax = (int) scan_ctl(argc, argv, "CONV_ITMAX", -1, "30", NULL);
00741   ret->conv_dmin = scan_ctl(argc, argv, "CONV_DMIN", -1, "0.1", NULL);
00742
00743   /* Error analysis... */
00744   ret->err_ana = (int) scan_ctl(argc, argv, "ERR_ANA", -1, "1", NULL);
00745
00746   for (id = 0; id < ctl->nd; id++)
00747     ret->err_formod[id] = scan_ctl(argc, argv, "ERR_FORMOD", id, "0", NULL);
00748
00749   for (id = 0; id < ctl->nd; id++)
00750     ret->err_noise[id] = scan_ctl(argc, argv, "ERR_NOISE", id, "0", NULL);
00751
00752   ret->err_press = scan_ctl(argc, argv, "ERR_PRESS", -1, "0", NULL);
00753   ret->err_press_cz = scan_ctl(argc, argv, "ERR_PRESS_CZ", -1, "-999", NULL);
00754   ret->err_press_ch = scan_ctl(argc, argv, "ERR_PRESS_CH", -1, "-999", NULL);
00755
00756   ret->err_temp = scan_ctl(argc, argv, "ERR_TEMP", -1, "0", NULL);
00757   ret->err_temp_cz = scan_ctl(argc, argv, "ERR_TEMP_CZ", -1, "-999", NULL);
00758   ret->err_temp_ch = scan_ctl(argc, argv, "ERR_TEMP_CH", -1, "-999", NULL);
00759
00760   for (ig = 0; ig < ctl->ng; ig++) {
00761     ret->err_q[ig] = scan_ctl(argc, argv, "ERR_Q", ig, "0", NULL);
00762     ret->err_q_cz[ig] = scan_ctl(argc, argv, "ERR_Q_CZ", ig, "-999", NULL);
00763     ret->err_q_ch[ig] = scan_ctl(argc, argv, "ERR_Q_CH", ig, "-999", NULL);
00764   }
00765
00766   for (iw = 0; iw < ctl->nw; iw++) {
00767     ret->err_k[iw] = scan_ctl(argc, argv, "ERR_K", iw, "0", NULL);
00768     ret->err_k_cz[iw] = scan_ctl(argc, argv, "ERR_K_CZ", iw, "-999", NULL);
00769     ret->err_k_ch[iw] = scan_ctl(argc, argv, "ERR_K_CH", iw, "-999", NULL);
00770   }
00771 }
00772
00773 /*****************************************************************************/
00774
00775 void set_cov_apr(
00776   ret_t * ret,
00777   ctl_t * ctl,
00778   atm_t * atm,
00779   int *iqa,
00780   int *ipa,
00781   gsl_matrix * s_a) {
00782
00783   gsl_vector *x_a;
00784
00785   double ch, cz, rho, x0[3], x1[3];
00786
00787   int ig, iw;
00788
00789   size_t i, j, n;
00790
00791   /* Get sizes... */
00792   n = s_a->size1;
00793
00794   /* Allocate... */
00795   x_a = gsl_vector_alloc(n);
00796
00797   /* Get sigma vector... */
00798   atm2x(ctl, atm, x_a, NULL, NULL);
00799   for (i = 0; i < n; i++) {
00800     if (iqa[i] == IDXP)
00801       gsl_vector_set(x_a, i, ret->err_press / 100 * gsl_vector_get(x_a, i));
00802     if (iqa[i] == IDXT)
00803       gsl_vector_set(x_a, i, ret->err_temp);
00804     for (ig = 0; ig < ctl->ng; ig++)
00805       if (iqa[i] == IDXQ(ig))
00806         gsl_vector_set(x_a, i, ret->err_q[ig] / 100 * gsl_vector_get(x_a, i));
00807     for (iw = 0; iw < ctl->nw; iw++)
00808       if (iqa[i] == IDXK(iw))
00809         gsl_vector_set(x_a, i, ret->err_k[iw]);
00810   }
00811
00812   /* Check standard deviations... */
00813   for (i = 0; i < n; i++)
00814     if (POW2(gsl_vector_get(x_a, i)) <= 0)
00815       ERRMSG("Check a priori data (zero standard deviation)!");
00816
```

```
00817   /* Initialize diagonal covariance... */
00818   gsl_matrix_set_zero(s_a);
00819   for (i = 0; i < n; i++)
00820     gsl_matrix_set(s_a, i, i, POW2(gsl_vector_get(x_a, i)));
00821
00822   /* Loop over matrix elements... */
00823   for (i = 0; i < n; i++)
00824     for (j = 0; j < n; j++)
00825       if (i != j && iqa[i] == iqa[j]) {
00826
00827         /* Initialize... */
00828         cz = ch = 0;
00829
00830         /* Set correlation lengths for pressure... */
00831         if (iqa[i] == IDXP) {
00832           cz = ret->err_press_cz;
00833           ch = ret->err_press_ch;
00834         }
00835
00836         /* Set correlation lengths for temperature... */
00837         if (iqa[i] == IDXT) {
00838           cz = ret->err_temp_cz;
00839           ch = ret->err_temp_ch;
00840         }
00841
00842         /* Set correlation lengths for volume mixing ratios... */
00843         for (ig = 0; ig < ctl->ng; ig++)
00844           if (iqa[i] == IDXQ(ig)) {
00845             cz = ret->err_q_cz[ig];
00846             ch = ret->err_q_ch[ig];
00847           }
00848
00849         /* Set correlation lengths for extinction... */
00850         for (iw = 0; iw < ctl->nw; iw++)
00851           if (iqa[i] == IDXK(iw)) {
00852             cz = ret->err_k_cz[iw];
00853             ch = ret->err_k_ch[iw];
00854           }
00855
00856         /* Compute correlations... */
00857         if (cz > 0 && ch > 0) {
00858
00859           /* Get Cartesian coordinates... */
00860           geo2cart(0, atm->lon[ipa[i]], atm->lat[ipa[i]], x0);
00861           geo2cart(0, atm->lon[ipa[j]], atm->lat[ipa[j]], x1);
00862
00863           /* Compute correlations... */
00864           rho =
00865             exp(-DIST(x0, x1) / ch -
00866                 fabs(atm->z[ipa[i]] - atm->z[ipa[j]]) / cz);
00867
00868           /* Set covariance... */
00869           gsl_matrix_set(s_a, i, j, gsl_vector_get(x_a, i)
00870                          * gsl_vector_get(x_a, j) * rho);
00871         }
00872       }
00873
00874   /* Free... */
00875   gsl_vector_free(x_a);
00876 }
00877
00878 /*****************************************************************************/
00879
00880 void set_cov_meas(
00881   ret_t * ret,
00882   ctl_t * ctl,
00883   obs_t * obs,
00884   gsl_vector * sig_noise,
00885   gsl_vector * sig_formod,
00886   gsl_vector * sig_eps_inv) {
00887
00888   static obs_t obs_err;
00889
00890   int id, ir;
00891
00892   size_t i, m;
00893
00894   /* Get size... */
00895   m = sig_eps_inv->size;
00896
00897   /* Noise error (always considered in retrieval fit)... */
00898   copy_obs(ctl, &obs_err, obs, 1);
00899   for (ir = 0; ir < obs_err.nr; ir++)
00900     for (id = 0; id < ctl->nd; id++)
00901       obs_err.rad[id][ir]
00902         = (gsl_finite(obs->rad[id][ir]) ? ret->err_noise[id] : GSL_NAN);
00903   obs2y(ctl, &obs_err, sig_noise, NULL, NULL);
```

```
00904
00905   /* Forward model error (always considered in retrieval fit)... */
00906   copy_obs(ctl, &obs_err, obs, 1);
00907   for (ir = 0; ir < obs_err.nr; ir++)
00908     for (id = 0; id < ctl->nd; id++)
00909       obs_err.rad[id][ir]
00910         = fabs(ret->err_formod[id] / 100 * obs->rad[id][ir]);
00911   obs2y(ctl, &obs_err, sig_formod, NULL, NULL);
00912
00913   /* Total error... */
00914   for (i = 0; i < m; i++)
00915     gsl_vector_set(sig_eps_inv, i, 1 / sqrt(POW2(gsl_vector_get(sig_noise, i))
00916                                             +
00917                                             POW2(gsl_vector_get
00918                                                  (sig_formod, i))));
00919
00920   /* Check standard deviations... */
00921   for (i = 0; i < m; i++)
00922     if (gsl_vector_get(sig_eps_inv, i) <= 0)
00923       ERRMSG("Check measurement errors (zero standard deviation)!");
00924 }
00925
00926 /*****************************************************************************/
00927
00928 void write_stddev(
00929   const char *quantity,
00930   ret_t * ret,
00931   ctl_t * ctl,
00932   atm_t * atm,
00933   gsl_matrix * s) {
00934
00935   static atm_t atm_aux;
00936
00937   gsl_vector *x_aux;
00938
00939   char filename[LEN];
00940
00941   size_t i, n;
00942
00943   /* Get sizes... */
00944   n = s->size1;
00945
00946   /* Allocate... */
00947   x_aux = gsl_vector_alloc(n);
00948
00949   /* Compute standard deviation... */
00950   for (i = 0; i < n; i++)
00951     gsl_vector_set(x_aux, i, sqrt(gsl_matrix_get(s, i, i)));
00952
00953   /* Write to disk... */
00954   copy_atm(ctl, &atm_aux, atm, 1);
00955   x2atm(ctl, x_aux, &atm_aux);
00956   sprintf(filename, "atm_err_%s.tab", quantity);
00957   write_atm(ret->dir, filename, ctl, &atm_aux);
00958
00959   /* Free... */
00960   gsl_vector_free(x_aux);
00961 }
```

5.29 time2jsec.c File Reference

Convert date to Julian seconds.

Functions

- int main (int argc, char *argv[])

5.29.1 Detailed Description

Convert date to Julian seconds.

Definition in file time2jsec.c.

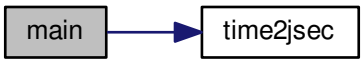
5.29.2 Function Documentation

5.29.2.1 int main (int *argc*, char * *argv[]*)

Definition at line 27 of file time2jsec.c.

```
00029                {
00030
00031   double jsec, remain;
00032
00033   int day, hour, min, mon, sec, year;
00034
00035   /* Check arguments... */
00036   if (argc < 8)
00037     ERRMSG("Give parameters: <year> <mon> <day> <hour> <min> <sec> <remain>");
00038
00039   /* Read arguments... */
00040   year = atoi(argv[1]);
00041   mon = atoi(argv[2]);
00042   day = atoi(argv[3]);
00043   hour = atoi(argv[4]);
00044   min = atoi(argv[5]);
00045   sec = atoi(argv[6]);
00046   remain = atof(argv[7]);
00047
00048   /* Convert... */
00049   time2jsec(year, mon, day, hour, min, sec, remain, &jsec);
00050   printf("%.2f\n", jsec);
00051
00052   return EXIT_SUCCESS;
00053 }
```

Here is the call graph for this function:



5.30 time2jsec.c

```
00001 /*
00002   This file is part of JURASSIC.
00003
00004   JURASSIC is free software: you can redistribute it and/or modify
00005   it under the terms of the GNU General Public License as published by
00006   the Free Software Foundation, either version 3 of the License, or
00007   (at your option) any later version.
00008
00009   JURASSIC is distributed in the hope that it will be useful,
00010   but WITHOUT ANY WARRANTY; without even the implied warranty of
00011   MERCHANTABILITY or FITNESS FOR A PARTICULAR PURPOSE.  See the
00012   GNU General Public License for more details.
00013
00014   You should have received a copy of the GNU General Public License
00015   along with JURASSIC. If not, see <http://www.gnu.org/licenses/>.
00016
00017   Copyright (C) 2003-2015 Forschungszentrum Juelich GmbH
00018 */
00019
00025 #include "jurassic.h"
00026
00027 int main(
00028   int argc,
00029   char *argv[]) {
```

```
00030
00031   double jsec, remain;
00032
00033   int day, hour, min, mon, sec, year;
00034
00035   /* Check arguments... */
00036   if (argc < 8)
00037     ERRMSG("Give parameters: <year> <mon> <day> <hour> <min> <sec> <remain>");
00038
00039   /* Read arguments... */
00040   year = atoi(argv[1]);
00041   mon = atoi(argv[2]);
00042   day = atoi(argv[3]);
00043   hour = atoi(argv[4]);
00044   min = atoi(argv[5]);
00045   sec = atoi(argv[6]);
00046   remain = atof(argv[7]);
00047
00048   /* Convert... */
00049   time2jsec(year, mon, day, hour, min, sec, remain, &jsec);
00050   printf("%.2f\n", jsec);
00051
00052   return EXIT_SUCCESS;
00053 }
```

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